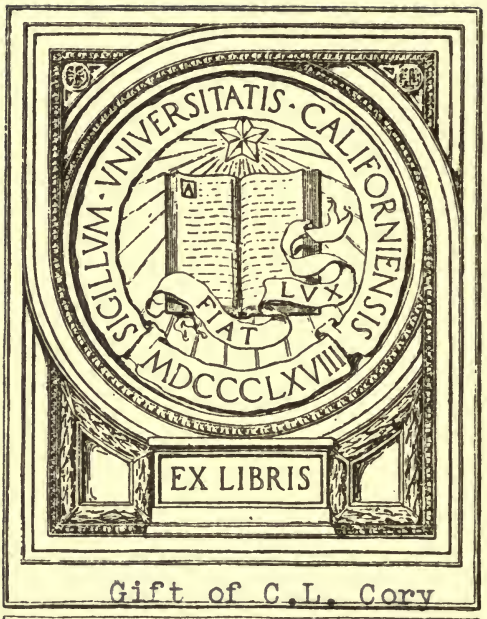
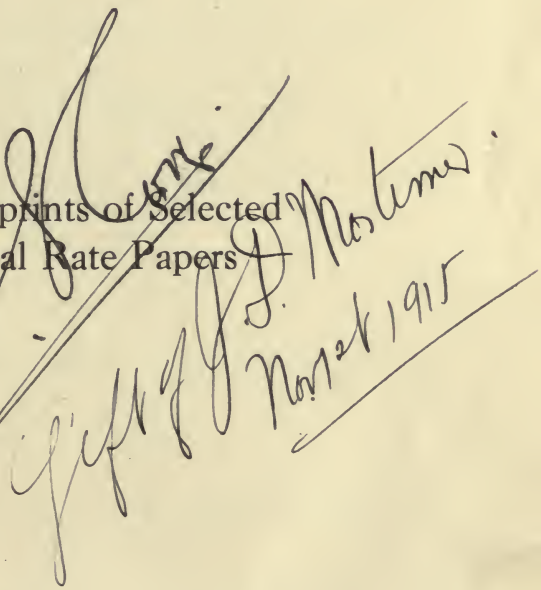


The Development *of* Scientific Rates *for* Electricity Supply

Being Reprints of Selected Original Rate Papers



Printed for Private Circulation Only
by
The Edison Illuminating Company of Detroit
1915

NOTE.

Paragraph headings and index pages have been inserted for convenience. The majority of these headings, and the index pages, are not in the original papers.

CONTENTS

On the Cost of Electric Supply

by

DR. JOHN HOPKINSON

Presidential Address to the
Junior Engineering Society

November 4th, 1892

(From the Transactions of the Junior Engineering Society,
Vol. III, Part I, pp. 1–14)

INDEX

On the Cost of Electric Supply

By Dr. John Hopkinson

1892

Introduction

The interests of an Engineer are many sided. If he is to successfully use the forces of nature for the service of man he must understand how those forces work; he must in fact be scientific. It may be that his ideas are arranged differently from the ideas of those who study science for its own sake, and without regard to practical applications, but if he is to succeed they must be so arranged that he can deduce from knowledge already acquired, knowledge which is applicable to new cases which have not as yet come under his observation. The Engineer who can only do that which he has seen done before may be a practical man, but he will always belong to a lower grade of his profession. The scientific Engineer is one who by his knowledge of nature is able to deal with new engineering problems and provide useful solutions of those problems. But a practical man must be something more than a man of science, or rather he must look at matters from a different point of view. He cannot choose some feature of a problem, concentrate all his attention upon that, and leave other matters out of consideration, which is the process by which most scientific advance has been made; but he must always deal with the whole matter before him and leave no relevant question out. But an Engineer may be scientific inasmuch as he has knowledge of nature and the power of applying that knowledge in new cases; he may be practical in the sense that the means he devises to attain his ends may be complete at all points, and not break down from trifling defects, and yet may find that there are other subjects which he has to consider. Our complete Engineer must give his attention to commercial matters as well; he must know if, when he has devised the means to attain the ends in view, those ends when attained will result in a profit. He must recognise the conditions which render an undertaking economical to work, and which secure that it shall bring in a large return.

When it has been my lot to address Engineers I have usually directed attention to some scientific point which I thought would be of interest to them. This evening I should like to go to the other extreme and deal with a purely commercial question, with a matter into which no science enters, and which relates entirely to pounds, shillings and pence.

Standing Costs and Running Costs

You are all of you familiar with the fact that the expenses of an undertaking may be broadly divided into two classes. On the one hand there are expenses which are quite independent of the extent to which the undertaking is used, and on the other, expenses which are absent unless the undertaking is used and which increase in proportion to the use. For example, the charges for interest on the construction of a bridge are the same whether that bridge is used much or little or at all, and the cost of maintaining the bridge is also practically independent of its user. The same is true in a large measure of a harbour or a dock. Such undertakings lie at one extreme of the scale. It is less easy to find good examples at the present day of the other extreme, as nearly all undertakings with which Engineers have to deal require the employment of some capital, and there will be a fixed charge for the use of that capital and for maintaining against the assaults of time the things in which the capital is embodied. But we can readily see for example in the case of a cotton mill that, if on the one hand there are expenses for interest and dilapidation which are independent of the amount of yarn actually manufactured in a given factory, there are other expenses for material and labour, and even for actual wear of machinery which will be very nearly proportional to the output. Undertakings vary enormously in the proportion of these two classes of expenses, in some the expense is quite independent of the extent of the user, in others it is for the greater part proportional to the user.

Load Factor

But undertakings differ from each other in another respect. In some cases the service which the undertaking is designed to render can be performed at a time selected by the undertakers; in others at a time selected by him to whom the service is rendered. In the case of most manufactures it matters not if the thing made is made to-day or to-morrow, in the morning or the evening, for it will not

be used for a month hence perhaps; the thing can in fact be extensively stored and kept till it is wanted. Other services must be rendered at the moment the person served desires. For example, the Metropolitan District Railway must be prepared to bring in its thousands of passengers to the City at the beginning of the day and to take them back in the evening, and for the rest of the day it must be content to be comparatively idle. In this case the services cannot be stored. The line must be of a carrying capacity equal to the greatest demand, and if this be great for a very short time the total return for the day must be small in comparison with the expense of rendering the service. In such a case it would not be inappropriate to charge more for carrying a person in the busy time than in the slack time, for it really costs more to carry him.

Let us see how these considerations apply to the supply of electricity for lighting. Electrical Engineers now realise that they have to provide the same plant and no more to give a steady supply day and night as to give a supply for one hour out of the twenty-four. They also now realise that if they are to be ready to give a supply at any moment, they must burn much coal and pay much wages for however short a time the supply is actually taken. Indeed, the term "load factor" proposed by Mr. Crompton is as constantly in the mouths of those who are interested in the supply of electricity, as volt or ampere or horse-power. The importance of the time during which a supply of electricity is used was so strongly impressed on my mind years ago that in 1883 I had introduced into the Provisional Orders with which I had to do, a special method of charge intended to secure some approach to proportionality of charge to cost of supply. Unfortunately the orders of that day all came to nought.

A supply of electricity must be delivered at the very moment when the consumer chooses to use it, and as long as and no longer than he pleases to use it; it cannot be very readily or cheaply stored, and much of the cost of production is the fixed charge for plant and conductors. Furthermore the provisional orders require that the supply shall be available at all hours; hence coal must be consumed and workmen must attend, though but few consumers are drawing a supply. The service of supplying electricity has from an economic point of view a great deal of similarity to the service of providing a breakwater for a harbour. A great deal of the expense is independent of the number of hours in the day during which the supply is used. To put it in another way, the cost of

supplying electricity for 1,000 lamps for ten hours is very much less than ten times the cost of supplying the same 1,000 lamps for one hour, particularly if it is incumbent on the undertaker to be ready with a supply at any moment that it is required.

The actual importance of considerations of this kind can only be realised by examining figures. The figures may as well be estimated figures, because the circumstances vary from one neighbourhood to another. No criticism of the details of the figures will affect the general character of the conclusion. Let us then imagine a station capable of supplying 40,000 sixteen-candle lamps at one time, with mains and spare machinery enough to ensure that the supply shall not fail, and let us see what the charge for running such a station will be; firstly on the hypothesis that it is always to be ready to supply the 40,000 lights at half-an-hour's notice day or night but that the lights are hardly ever actually required; secondly on the hypothesis that the 40,000 lights are steadily and continuously supplied day and night. These are the two extreme cases possible. In the former, the load factor is nil; in the latter it is 100 per cent. If the charge is by meter at 8d. per unit in the former case, the revenue will be nil; in the latter it will be £730,000 a year.

Apportionment of Costs

We are going to divide the cost of supplying electricity into two parts; a part which is independent of the hours the supply is used, and a part which is directly proportional thereto; and we are going to estimate the amount of each element. It is for the purpose of ascertaining these elements that we consider two quite hypothetical cases; cases which can themselves never actually occur.

We must first have an idea of the capital outlay required. To provide the maximum of 40,000 lamps we need to deliver 2,500 units per hour, and we may estimate the capital outlay as follows:—

	£
Land	25,000
Buildings	15,000
Boilers and Pipes	14,000
Engines	24,000
Dynamos	15,000
Switchboard and Instruments	2,000
Feeders and Mains	50,000
	£145,000

Let us deal with the annual charge for each item of capital separately on the two hypotheses. The charge for land and for buildings including repairs is clearly the same in the two cases, say at 4 per cent. £1,000 for the land, and at 10 per cent. £1,500 for the buildings. The boilers, engines, and dynamos will have a charge for interest, and a charge for writing off or amortization as the French call it, that is, for writing off the value of the plant before the time at which it becomes antiquated—exactly the same in the two cases. The boilers too will require exactly the same repairs whether they are merely keeping steam or whether they are generating steam continuously; but the machinery will certainly require more for repairs and renewals if it is all running than if a part only is running without load and the rest is standing ready for a load if required. I take 4 per cent. as the charge for interest; 3 per cent. for amortization; 8 per cent. for repairs and maintenance. Of the repairs of engines and dynamos I assume that 2 per cent. will be applicable if the plant runs light, the remaining 6 per cent. if it is fully and continuously loaded. The expenses connected with conductors and switchboard, etc., will be exactly the same whether the current is passing or not; these I take at 15 per cent. The rates I put down at £500 a year. The account then for the fixed charges already enumerated would stand as follows:

	Running Light £	Fully Loaded £
Land	1,000	1,000
Buildings	1,500	1,500
Rates	500	500
Boilers	2,100	2,100
Switchboard and Conductors	7,800	7,800
Engines	2,160	3,600
Dynamos	1,350	2,250
	£16,410	£18,750

We now come to a most important item in the account, the coal. There is no doubt that with uniform and continuous load a unit of electric energy—1⅓ horse-power for one hour—can be produced for less than 3 lbs. of coal; it is also pretty much admitted that with a load factor of about 12 per cent., but continuous maintenance of pressure, the consumption of coal in good practice is something like 7 lbs. That is to say, to keep the boilers warm, turn round the machinery for 24 hours, and deliver full current for 24 hours, will require 72 lbs. of coal per kilowatt; whereas to keep the boilers warm, turn round the machinery, and deliver current for 3 hours, will

require 21 lbs. of coal. The boilers being kept warm, it will take 51 lbs. of coal to generate steam enough to give a unit per hour for 21 hours; 58 lbs. to give a unit per hour for 24 hours; subtracting this from 72 lbs., the amount required both to generate steam and keep the boiler warm, we may infer that to keep the boiler warm and merely turn the machinery in readiness to meet a demand will take about 14 lbs. of coal per day for every unit per hour the plant is capable of producing. In 1889, for the Society of Arts, tests were made of a Paxman compound engine, from which it appears that a boiler which when fully loaded consumed 40 lbs. of coal per hour, required 4 lbs. per hour to keep steam up to normal pressure when the engine was standing: that is, 10 per cent. of the coal used was used to maintain the steam pressure. Remembering that in addition we keep some of our machinery moving, this may be said to confirm the figures adopted. Thus if the plant runs light all the year round 12,775,000 lbs., or let us say 6,000 tons of coal will be consumed. If the plant runs fully loaded 65,700,000 lbs., or let us say 30,000 tons would be consumed. If we suppose the coal to be best smokeless it might cost 20s. per ton.

Next we have water, oil and petty stores; say £600 and £3,000 in the two cases. Wages will be a little less if we run light than if we run fully loaded, and of course will largely depend on local circumstances; let us say £5,000 and £7,500 in the two cases. This gives us substantially all the expenses which have to be met and our account will then stand thus:

	Running Light £	Fully Loaded £
Fixed Charges	16,410	18,750
Coal	6,000	30,000
Stores	600	3,000
Wages	5,000	7,500
	£28,010	£59,250

Thus the cost of merely being ready to supply 2,500 units per hour at any moment throughout the year will be £28,010, and the cost of actually supplying 2,500 units per hour for every minute in the year will be £59,250. The undertaker therefore who incurs the liability to supply, ought to receive £11 per annum per unit per hour from those on whose behalf he incurs the liability, and if he receives the £11 he need not charge more than ⅓d. per unit for what he actually supplies, to cover his expenses. That these figures are fair approximations can be seen as follows: according

to this calculation the cost of supplying 2,500 units for one hour per day is £28,010+2,500×365×½d.=£29,277, and the charge for the service at 8d. a unit would be £30,417; it is doubtful if such a supply would pay. On the other hand an indicated horse-power on such a scale could certainly be supplied continuously for from £12 to £14 per annum, and according to this calculation an electrical horse-power will cost just under £18 per annum. No account is taken of expenses peculiar to companies, such as directors' fees and the cost of forming the company. It will also be noted that it is assumed that accumulators are not used.

Form of Charge

The charge for a service rendered should bear some relation to the cost of rendering it. If it is a matter of open competition the matter will settle itself, for no one will for long be able to supply some customers at a loss, and recoup himself by exorbitant profits from others. If the matter be a case more or less of monopoly, the adjustment is less certain; thus the Post Office charges ½d. postage for a printed circular and 1d. for a written letter, the two costing the Post Office exactly the same. What a boon to the public it would be if the Post Office would charge more for printed trade circulars, which in nine cases out of ten are a nuisance to those who receive them. The supply of electricity is not quite a monopoly; companies compete with each other, and there is always the competition with other methods of illumination such as gas and paraffin. It is clearly to the advantage of the undertaker to secure all those customers whom it pays best to supply, and as far as may be, to compel those who are unremunerative to adopt these other methods. The ideal method of charge then is a fixed charge per quarter proportioned to the greatest rate of supply the consumer will ever take, and a charge by meter for the actual consumption. Such a method I urged in 1883, and obtained the introduction into certain Provisional Orders of a clause sanctioning "a charge which is calculated partly by the quantity of energy contained in the supply and partly by a yearly or other rental depending upon the maximum strength of the current required to be supplied." In fixing the rates of fixed charge it must not be forgotten that it is improbable that all consumers will demand the maximum supply at the same moment and consequently the fixed charge named might be reduced or some profit be obtained from it. There is no object in reducing the cost of electricity for lighting in the case of any customer much below

the cost of equivalent lighting by gas, unless there are competitors in the field willing to do it, hence the current charge proportioned to the power supplied may safely be increased. In certain recent cases in which I am acting as engineer, the Board of Trade have sanctioned on my application, "for each unit per hour in the maximum power demanded, a charge not exceeding £3 per quarter, and in addition for each unit supplied, a charge not exceeding two pence." It is sometimes said as an objection to this method of charge, the public will object to pay a fixed charge whether they make use of their lights or not, and that in fact they will not pay it. The best answer that can be made is to give everyone the choice of being charged the maximum simple rate provided by the Order, or by the compound rate, as they prefer. What is wanted is not so much an increased charge for those consumers whose lights are used for a short time, as such a special reduced charge for those whose lights are used long as will induce them to use the supply.

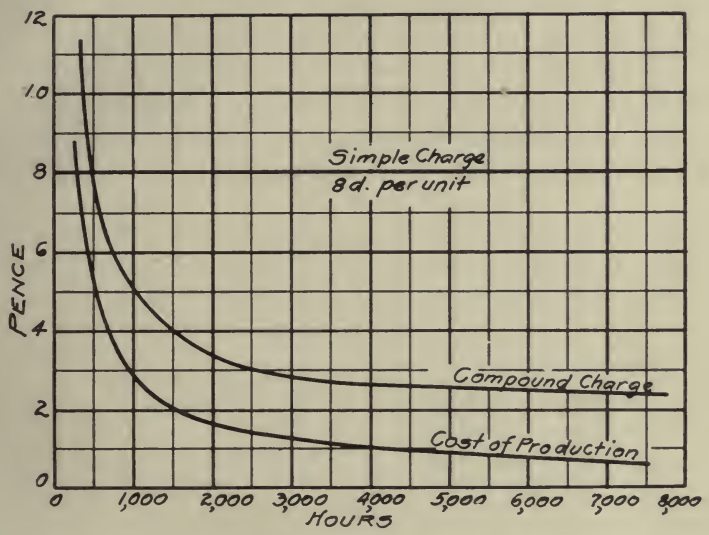
Comparison with Costs for Gas

It is instructive to compare the cost to different classes of consumers of electricity and gas for lighting with 16-candle gas. Flat flame burners must be large and of first-rate quality to give more than two candles per cubic foot of gas per hour; the large majority of burners give much less than this even at their best, and as a rule the pressure of the gas is not regulated and much gas is wasted as far as the production of light is concerned. Incandescent lamps give about one-quarter of a candle per watt; hence a Board of Trade unit is equivalent to 125 cubic feet of gas. Thus we readily arrive at the following comparative table, the charge being at the rates recently sanctioned by the Board of Trade:—

Hours of use per annum	Load Factor	Price of Gas at which cost of lighting by electricity and 16-candle gas are equal
480	5·5	5s. 4d.
960	10·9	3s. 4d.
1,440	16·4	2s. 8d.
1,920	21·9	2s. 4d.
2,880	32·9	2s. 0d.
3,840	43·8	1s. 10d.
7,680	87·6	1s. 7d.

In the accompanying curves are shown the cost of production, and the charge per unit at the compound and simple rate. The ordinates represent pence and the abscissæ the number of hours per annum the supply is used.

It is obvious that those whose user is long will find the electric light economical to themselves and that it will be profitable to the undertaker. With a cheap light which is free from the products of combustion there will be extensions for the hours of use. Shops may find it worth while to continue the light after closing, as an advertisement.



Effect of Use of Accumulators

We have so far assumed that the supply of electricity is carried on without the aid of accumulators. Let us first compare the cost of an electric accumulator with the cost of a gas-holder containing the same possibility of producing light. A gas-holder is at present being put up in Manchester to hold 7,000,000 cubic feet of gas and is to cost complete with its tank £60,000. With 16-candle gas seven million cubic feet are equivalent to 56,000 Board of Trade units. Accumulators, capable of storing a ten hours' supply, cost about £50 per unit. The equivalent accumulator will therefore cost about £280,000. But this is not all; the gas-holder is comparatively permanent; the accumulators require frequent renewals and repairs; the gas-holder gives back all the energy put into it; the accumulators waste at least 20 per cent.; the gas-holder may be emptied as fast as you please; the accumulators, not faster than a certain rate without diminishing their capacity. Taking all into

consideration, the cost of storing energy by the aid of accumulators and storing it in a gas-holder are quantities of a different order of magnitude. If no gas-holders were used, and all the gas had to be made just as it was wanted, its cost for lighting would be several fold what it now is, even if gas-producers could be found capable of instantly varying the supply as the demand varies. The gas-producing plant would have to be enormously increased; so would the size of the mains, and so would the wages of labour. If electric power could be stored as cheaply as gas, there would soon be little hope that the gas companies would maintain their dividends.

Let us see from a financial point of view whether accumulators can be used economically for storing up electrical power continuously produced during the 24 hours, and used rapidly for a short time.

Assume that the whole of the plant with the accumulators is capable of supplying 40,000 lights for ten hours continuously, and that during that time half the power is supplied from the accumulators. Ten hours in the twenty-four hours is not an unreasonable allowance, for we have melancholy experience in London of continuous fog for days, and this would tax the plant we are considering to the utmost. We are to be ready then at any time on short notice to supply 40,000 lights, and to continue to supply them for 10 hours. Compare the cost firstly of maintaining this state of readiness with the accumulators and with a plant without accumulators. We shall require a battery capable of giving 1,250 units for ten hours; such a battery costs not less than £50 per unit, or in all £62,500. To maintain it, will cost from 10 to 15 per cent. on the cost; there will also be interest on the outlay and amortization, say in all 20 per cent. or £12,500 a year. If we assume that the batteries are distributed at the various points of the system of conductors, we may also assume that the charges for land and buildings will be much the same as for the plant without accumulators. The boilers, engines, and dynamos will be just one-half. The switchboard and instruments will be much the same. But the conductors will be reduced, smaller or shorter feeders being necessary, probably £40,000 will go as far with accumulators as £50,000 without. The coal bill may be dispensed with entirely, as we may assume that steam could always be got up during the time in which the demand increased from nothing to one-half of the maximum, and that therefore all the coal burned can be assumed to be burned for producing current. That is to say, we assume the quantity of coal

burned is proportional to the quantity of electric energy, and that therefore when no electricity is actually used, no coal will be burned. The wages may be reduced, for we have only to be ready to run half the plant, and a small wage will suffice for attendance on the accumulators. The wages of linesmen and the like will remain the same. Assume the total wages to be £3,500 instead of £5,000. The account will then stand thus:—

	£
Land	1,000
Buildings	1,500
Rates	500
Accumulators	12,500
Boilers	1,050
Engines	1,080
Dynamos	675
Switchboard	300
Conductors	6,000
Wages	3,500
	£28,105

practically the same result as we obtained before.

Now consider another hypothetical case, which of course can never occur in practice. We are to supply 40,000 lamps for ten hours every day with the plant just described, charging the accumulators during twelve and a half of the fourteen hours during which the light is not required, twelve and a half hours' charging giving ten hours' discharge of the same energy. The coal would cost the half of £30,000 if the machinery had to run the whole of the 24 hours. It has to run 22½ hours, but the boilers have to be kept warm the whole time, hence the coal will cost the half of £6,000 for keeping the boilers warm, and $\frac{22\frac{1}{2}}{24}$ of the half of £24,000 for generating steam. The wages may fairly be taken as £4,750, and the account will stand:—

	£
Land	1,000
Buildings	1,500
Rates	500
Accumulators	12,500
Boilers	1,050
Engines	1,800
Dynamos	1,125
Switchboard	300
Conductors	6,000
Wages	4,750
Coal	14,250
Stores	1,425
	£46,200

The cost of supply for the same ten hours without accumulators would be as follows:—

	£
Land	1,000
Buildings	1,500
Rates	500
Boilers	2,100
Switchboard and Conductors	7,800
Engines	2,760
Dynamos	1,725
Coal	16,000
Stores	1,600
Wages	6,000
	£40,985

a cost of about 11 per cent. less than where accumulators are used.

Putting it another way, the cost of being ready to supply and to continue to supply, is about the same whether accumulators are used or not; the additional cost of actually supplying current is about 40 per cent. more where accumulators are used than where they are not used. It may be safely inferred that the use of accumulators does not seriously alter the conclusions I have drawn as to the proper method of charging consumers for a supply of electricity.

The question of whether the great cost of a supply for short hours can be removed by the use of accumulators may be looked at in another way. Will it pay a consumer to put in his own accumulators and charge them from the station supply? We may reasonably suppose the undertaker will remit the fixed charge in consideration of the consumer only taking his current at slack times. His accumulators if they are to be of capacity to maintain his supply through a foggy day will cost him £50 per unit per hour (or per kilowatt) and the annual charge in respect of them will be £10 per year, to which if we add a rent for the space the battery occupies, gives us a charge not differing materially from the fixed charge made or suitable to be made by the undertaker. But in order to obtain 2d. worth of electricity he must purchase 2½d. worth for charging his battery.

A word or two more about the use of accumulators. These have certainly improved, and they will continue to improve. They will become more durable and more economical of power in working, and their first cost will become less. An inspection of my tables of

cost shows that a very little improvement would render them valuable even in very large stations for the mere purpose of diminishing the machinery required, by storing the energy developed at slack times to be used in busy times. The certainty of improvements in accumulators, and the possibility that the improvement may be considerable, is a strong argument for the use of the direct current wherever it is not precluded by the distance of transmission being too great.

It will be noted that I have assumed a very large station. Accumulators have another use which greatly increases their advantage in smaller stations. There are many hours in the twenty-four when it is absolutely certain that the demand will be small. If accumulators are used, the attendance of the staff may be dispensed with during those hours, and a considerable sum in wages will be saved. The proportion of wages to the whole of the charges is much greater in small stations than in large. In most small stations giving continuous supply, accumulators ought to be used notwithstanding their expenses and defects, and I believe the day is not far distant when they ought to be used in connection with most large stations also.

Effect of Use of Alternating Current

If instead of a continuous current, an alternating current with transformers is used, the modification in the account will be that the cost of conductors will be diminished, but the cost of transformers will have to be added. If the distances are small, the increased cost of transformers will exceed the saving in the conductors; if the distances are considerable, the cost of transformers will be less than the saving of conductors. In both cases the general character of the result will be the same as before, the cost of being prepared to give a supply will be considerable, and the cost of actually giving the supply will be much smaller than is generally supposed. Indeed with the alternating current this peculiarity will be even more marked, for the machinery has not only to be kept in motion however small the consumption may be, but a certain current must be maintained in every transformer. With the best transformers, this current may only have an energy 1½ per cent. of the energy of the current when the transformer is fully loaded. This would increase the coal bill in the case considered by about £500 per year whether the supply was used or not.

Conclusion

It is possible, indeed probable, that some of my assumed figures may be shown to be too high or too low for the generality of cases. It is of no moment; let each one take any figures he pleases within reason; let him assume that the supply of electricity is made by any system he pleases; he will arrive at a result broadly similar to mine. To be ready to supply a customer with electricity at any moment he wants it will cost those giving the supply not much less than £11 per annum for every kilowatt, that is for every unit per hour, which the customer can take, if he wishes, and afterwards to actually give the supply, will not cost very much more than ⅓d. per unit. This is the point I have been labouring to impress, for I take it, it is essential to the commercial success of Electric Supply. It is hopeless for electricity to compete with gas in this country all along the line, if price is the only consideration. But with selected customers, electricity is cheaper than gas. Surely it is the interest of those who supply electricity to secure such customers by charging them a rate having some sort of relation to the cost of supplying them.

A Method of Calculating the Cost of Furnishing Electric Current and a Way of Selling It

by

W. J. GREENE

(Reprinted from The Electrical World, Volume XXVII,
Feb. 29, 1896, pp. 222, 223)

INDEX

A Method of Calculating the Cost of Furnishing Electric Current and a Way of Selling It

By W. J. Greene

1896

Introduction

A manager of a central station has, directly or indirectly, two objects in view—the increasing of the revenue, and the decreasing of the expenses. A thorough knowledge of the cost of supplying current, and of the rates at which it should be sold, would naturally come under the first head, and is of great importance in insuring the permanent success of a lighting plant. The experience of the writer's own company on these features, and data formulated therefrom, may prove of some interest.

In January, 1888, the company commenced the supply of current for light, using the alternating-current system. In the Fall of 1888 a few meters were installed, and in the Spring of 1889 the use of meters was adopted exclusively, except for one or two lamps. The rate charged was one cent per ampere-hour on 50-volt current, regardless of the amount consumed. Lights were added very rapidly. The stockholders were continually called upon to provide means for enlargements to the station equipment, extensions to the circuits and purchases of converters and meters. The net earnings for a time increased in proportion to the increase in investments. In 1892, however, a very apparent falling off in the net earnings in proportion to the new capital invested was noticed. It became evident that something was wrong. Tables were therefore prepared, showing the expense of maintaining an equipment necessary to supply current for consumers having from one light and upward. In comparing these results with the actual receipts from the various consumers, it was found that only 25 per cent of residence consumers and 55 per cent of other classes used sufficient current to furnish a paying investment. A few years prior thereto fully 85 per cent of residence consumers and 95 per cent of other classes were considered profitable.

The Minimum Charge

To find that too much business was undermining the stability of the company and jeopardizing its success was startling. It was evident that radical changes in the method of selling current must be made. Various plans, suggested by the practice of different companies, were considered, and it was finally decided to adopt the custom, more or less prevalent, of making a minimum charge, the charge to be a sufficient amount to cover all expenses known to be incurred in adding a consumer. In these expenses interest on the investment and an amount to cover depreciation due to wear and tear, which would not show up in repairs during the earlier life of the plant, were included.

Elements of Cost

To determine the least amount for which the company can afford to accept consumers it is necessary to establish how changes in the equipment, consumers, or consumption of current affect the expenses. I have made the following groups which I think are reasonably correct:

First. Expenses affected by the equipment, from real estate to meters, and expressed by the relation of the maximum number of lights burned at one time during the year to the investment.

Second. Expenses affected by the number of consumers.

Third. Expenses affected by the amount of work done by engines, boilers, dynamos, etc., and shown by the output in watt-hours.

Fourth. Expenses practically unvarying, and practically independent of the size of the plant, the number of consumers or the amount of current supplied. These may be considered as the basic expenses, or the starting point at which expenses begin to increase more or less in proportion to any increase in the size of the plant, the number of consumers, or the amount of current generated. They are necessarily estimated expenses, and cover the cost of running the station with a unit suitable to provide for the day load, supplying current to the switchboard only. The company must depend on long-hour consumers to furnish necessary revenue to meet these expenses. This fourth group is divided into three classes—those dependent on capital invested in the day unit, those dependent on the management of such a unit without any consumers, and those dependent on the power necessary to maintain the potential at the switchboard.

Fifth. Expenses affected by the size of the meter required by the individual consumer. The meters are treated separately, because the size of the meters are not always proportional to the number of lamps installed.

Apportionment of Costs

The first group comprises, in our classification of accounts, such expenses as total charges, exclusive of meters, for interest, depreciation, taxes, insurance, engineers and helpers, building repairs, switchboard repairs, station wiring repairs, tool and instrument repairs, circuit repairs, converter repairs, and service line repairs.

The second group comprises total charges for management, clerical service, stationery and printing, general expenses, petty repairs, rents, office heating and lighting, furniture and fixture repairs and reading meters.

The third group comprises total charges for water, fuel, firemen and helpers, oil and waste, boiler compounds, boiler repairs, pump repairs, breeching repairs, piping repairs, engine repairs, shafting and pulley repairs, belting repairs and dynamo repairs.

The fourth group comprises:

First. Two engineers at nominal wages, interest, depreciation, taxes, insurance, building repairs, switchboard repairs, station wiring repairs and tools and instruments repairs, on the capital invested in the smallest unit suitable for supplying current for the day load.

Second. An estimated amount from charges in the second group, and intended to be an amount below which it might be considered such expenses could not be reduced, even if the plant were operated without a consumer.

Third. Two firemen, water, fuel, oil and waste, boiler compound, boiler repairs, pump repairs, breeching repairs, engine repairs, shafting and pulley repairs, belting repairs and dynamo repairs, necessary to keep the potential at the switchboard when running the smallest unit 24 hours per day.

The fifth group comprises: Interest, depreciation, taxes, insurance and repairs on meters, figured on the size of meter necessary for any desired number of lamps.

Calculation of Cost of Current

For simplicity, the following letters are used to represent the factors employed in these calculations:

F = the first group.

C = the second group.

W = the third group.

f = the first division under the fourth group.

c = the second division under the fourth group.

w = the third division under the fourth group.

M = the fifth group.

L = the maximum number of 16-cp lamps burned at one time during the year.

l = the number of lamps in any consumer's installation for which the cost is desired.

e = the energy consumed per 16-cp lamp in watts.

N = the number of consumers.

T = the total annual output in kw-hours measured at station switchboard.

P = the percentage of T lost in converter and line leakage.

1—P = the percentage of T used by consumers and lost in transmission, except that due to converter and line leakage, as provided for in P.

V = the efficiency of transmission, being the loss in conductors and converters, due to current used by consumers.

VT (1—P) = the amount of current registered by consumers' meters.

X = the minimum cost for which current can be supplied for l lamps.

Y = the cost for l lamps, above which the company can afford to make concessions.

Then:

(1) $\frac{l\,(F—f)}{L}$ = the annual cost of the $F—f$ expenses for an installation of l lamps.

(2) $\frac{l\,P\,(W—w)}{L}$ = the annual cost of the $W—w$ expenses for an installation of l lamps.

(3) $\frac{C—c}{N}$ = the cost of the $C—c$ expenses per consumer.

(4) $\frac{L\,(F—f)}{L} + \frac{l\,P\,(W—w)}{L} + \frac{C—c}{N} + M$ = The least annual amount for which a company can afford to accept a consumer, if he uses no current at all. To this amount must be added the cost of the $W—w$ expenses for a quantity of current, which at one cent per ampere-hour will equal the (4) expenses plus the $W—w$ expenses for the above quantity of current. This is found by dividing (4) by one minus the $W—w$ expenses per ampere-hour.

$$(5)\quad \frac{\frac{(W-w)\times(1-P)}{VT\times(1-P)}}{e} = \text{the } (W-w) \text{ expenses per lamp-hour, expressed in decimals of one cent.}$$

Hence:

$$(6)\quad X = \frac{\frac{l\,(F-f)+l\,P\,(W-w)}{L}+\frac{C-c}{N}+M}{1-\frac{(W-w)\,e}{TV}}$$

For residence lighting I give l a value of 3 for 5 lamps, 4 for 10 lamps, 5 for 15 lamps, 6 for 20 lamps, etc.; because, if such a consumer wishes to have provision made for a maximum of say, 20 lights, there would seldom be over six in use at one time unless an entertainment were taking place, in which case other places could be counted on to cut off enough lamps to make up for the difference between the estimated maximum and the agreed maximum. For the value of Y, I add to the interest account an allowance for profits, and to the depreciation account an allowance to provide for depreciation, due to the dropping in value of apparatus and improvements in the same, which may necessitate a remodeling of a plant before the original machinery is worn out. The estimated expenses of f, c and w are made zero, and thus all expenses are provided for. A factor Z is introduced to allow for the following:

If the maximum load would average, say four hours each and every day, the allowance would not be necessary, because every light contracted for as a burning light, could then be relied upon to earn sufficient to pay its proportion of all expenses. The minimum charge could then be made the same as the charge above from which discounts could be made. Few plants, however, can show a four-hour maximum peak, and the conditions of operation must be met by dividing the expenses not included in the minimum charge, among the longer hour consumers. I endeavor to accomplish this and arrive at the value of Z by dividing the average maximum four-hour load in December by the average maximum four-hour load in July.

Hence:

$$(7)\quad Y = Z\left\{\frac{\frac{l\,F+l\,P\,W}{L}+\frac{C}{N}+M}{1-\frac{W\,e}{T\,V}}\right\}$$

For a direct-current plant, P would be so small that the W expenses in the numerator could be omitted in the expressions for both X and Y.

By putting the proper expense account under F, C and W, and letting l and L refer to arc lamps or motors, rated in watts or horsepower, the formula would be equally applicable to arc light or power service. e would be energy in watts per arc lamp, or watts allowed per unit adopted in motor service.

The above reasoning or formulas may not be absolutely without error or faultless, but I believe that they are, on the whole, fairly correct, and the information to be obtained therefrom I find very valuable, especially in competing for long-hour consumers. Data from various stations, showing the expenses per lamp, made up of expenses that vary with the number of burning lamps; the expenses per consumer, made up of expenses that vary with the number of consumers; the expenses per kw-hour, made up of expenses that vary with the station output; and the percentage of the output lost in converter and line leakage, would surely be as beneficial to managers as the collection of data showing the watts per pound of coal.

Form of Contract for Service

Tables made showing the values of X for different installations of l lamps, give the minimum charge; and similar tables for Y give the charges above which a company can afford to make concessions.

The following, from our form of contract, will give the method of selling current adopted by our company:

First is a statement showing the number and size of lamps:

(1) "Of which the subscriber agrees to burn not more than _____ lamps of 16 candle-power, or equivalent, at any one time.

(2) "The subscriber agrees to use current during the term of _____ year from the time connection is made, and pay therefor on or before the 10th day of each month at the rate of one cent per ampere-hour on 50-volt current, or two cents per ampere hour on 100-volt current, as may be shown by statement of the meter.

(3) "The subscriber further agrees that the minimum amount to be paid for current, and the use of the company's apparatus, other than a meter of the ordinary size, under this application and con-

tract, shall be $_____ per year, averaging $_____ per month, and the company may at its option, render and collect the minimum bill each month, in which case, during those months of the year when more light is required and consumed by him than the minimum bill, the subscriber will be credited upon his monthly bills by such an amount as will equalize any sum paid in excess of the amount computed from the meter reading, providing, however, that he has paid the minimum amount of this contract pro-rated up to such a date."

For consumers who are entitled to concessions, the following is submitted for the third clause:

"In consideration of the reduced rates herein provided, the subscriber hereby agrees that the minimum amount to be paid for current in any month shall be _____ dollars.

"The company agrees to make discounts on bills paid before the 10th day of each month as follows:

On bill of	2	times	minimum	bill,	5	per	cent.
" " "	3	"	"	"	10	"	"
" " "	4	"	"	"	15	"	"
" " "	5	"	"	"	20	"	"
" " "	6	"	"	"	25	"	"
" " "	8	"	"	"	30	"	"
" " "	10	"	"	"	35	"	"

"The minimum charge in the above case is based on 60 cents per lamp for the first five lamps of 16-cp or equivalent, and on 30 cents per lamp for each additional lamp of 16-cp or equivalent."

Conclusion

Of course, this method is not as popular with short-hour consumers as the plan of charging a fixed rate per unit, regardless of consumption; but the plan is, without question, more equitable and just to all concerned. All pay the increased expenses they cause, and in this way the long-hour consumers are not made to pay for the losses otherwise caused by the short-hour consumers. It is also possible to make concessions without encountering the dangers to be met with in discounting all bills of a certain amount or over, as where all bills of, say, $10 per month, or over, are discounted, a consumer having 100 lights and a bill of only $10 per month will get a discount, whereas he should have created a bill of from $20 to $30 per month, before he had reimbursed the company for expenses actually incurred in order to provide him with light subject to his voluntary use.

The introduction of the minimum charge has checked the rapid rank growth which was bearing little fruit for the stockholders, and has given in its place a healthy and satisfactory increase in the company's business. About one person in one hundred will refuse to use the light, because he objects to the minimum charges, *on principle*. He thinks he is being compelled to pay something for nothing. A just and reasonable man, however, will soon see the fallacy of that argument. None will connect unless they either expect to use in excess of the minimum charge, or consider the light has sufficient value to make it worth the amount of the charge. A net increase of about 2000 lights, a decrease, with the above lamps added, of about 200 lights in the maximum station load, and a very satisfactory increase in the gross and net revenues have been made since the adoption of the minimum charge.

Cost of Electricity Supply

by

ARTHUR WRIGHT

Presented Before Municipal Electrical Association, Whitehall, England

June 11th, 1896

(Reprinted from Minutes of Municipal Electrical Association, 1896, pp. 1-8)

INDEX

Cost of Electricity Supply

By Arthur Wright

1896

Introduction

No manufacturing undertaking can be considered to trade on a sound commercial basis unless it has ascertained to some degree of accuracy the cost of supplying the commodity it produces. That the electricity supply business at present can hardly be said to pass this criterion of commercial soundness the author thinks will be generally admitted, when it is remembered that although electricity has been regularly supplied for over five years from many large undertakings in quantities exceeding a million units annually, yet at the present time no very definite basis has been agreed upon by which the cost of energy wasted in feeders, transformers, shunted meters, etc., can be estimated, or on which to arrange tariffs for such varying classes of consumers as street lamps, motors, business premises, electric tramways and other industries consuming the electric current.

Lack of Uniformity in Rate Practice

To illustrate this great diversity of tariffs and presumably the uncertainty as to the true basis for costs calculations, the author points out that in many towns discounts are given in proportion to the amount of electricity consumed, thus assuming that the cost of supplying electricity depends mainly on the quantity taken; in other towns rebates are given on the basis of the time of the day during which the electricity is consumed, or on the lengthened use of the lamps or plant consuming or producing the electricity. Again, in others, the electricity consumed in motors is charged at a different rate to that consumed in lamps, implying thereby that it costs less in the one case than in the other. Curious instances of the uncertainty of opinion on this subject, which is of the first importance to Central Station Managers, are afforded by the varying and often quite arbitrary figures charged for the electricity consumed in public street lamps, and by the compiler of Electricity Works Costs in a largely circulated technical journal who, in estimating the profit or loss made on the supply to public street lamps, has actually to as-

sume the cost of the electricity to these is the same as the average cost of all the electricity supplied from the Central Station.

A commercial undertaking supplying only one commodity such as electricity, ought surely to be able to show from its books where and how the profits or losses are made. Hitherto, however, Central Stations have had to be judged as to whether they are successful or not, solely on the net results of the year's trading, irrespective as to whether the profits or losses were made from all the consumers or from only a portion of them, because no proper method of keeping the Profit and Loss Account has been as yet agreed on among Central Station Managers.

The question now naturally arises, is there not some easy and practical method for doing away with the continued guess work at the cost of supplying electricity to the varying classes of consumers which is so often resorted to, and with the present great diversity of systems of tariff.

Of the many proposed methods devised for arriving at a solution of the complex problem of determining the cost of supplying electricity, the most obvious and easy is the usual one adopted by most of us, viz.: that of dividing the total annual expenditure or the amount debited to the Revenue Account of a Central Station undertaking by the total number of units delivered to the consumers, and to accept this actual average cost per unit as a sufficient guide for all purposes. Many business men, however, now recognise that this result is of no more use in deciding the question of which is the correct tariff by which to charge the various classes of consumers than would be, to a railway manager, the knowledge of the average cost of carrying passengers on his railway per mile, should he want to know for how little he could profitably carry a certain number of excursionists on a given day.

The Hopkinson Theory

Dr. Hopkinson, in his classical paper before the Junior Engineers, very clearly proved that the cost of supplying electricity *cannot be correctly defined at so much per unit unless the RATE of supplying that unit be also stated*, and showed that the cost depends much more on the greatest rate at which the electricity has to be supplied than it does on the amount actually supplied. He, moreover, urged that it was both morally unjust and commercially inexpedient to always charge a uniform rate for a manufactured

commodity which, in one case might very obviously require ten times as much plant for manufacturing it as it would in another, owing to its having possibly to be supplied at ten times as great a rate.

The results Dr. Hopkinson obtained from the very bold method of analysis adopted were so novel and surprising that perhaps this may account for so many of us still ignoring his conclusions, and partly doubting the accuracy of his method.

Recently, Mr. Edison and Mr. W. J. Greene, in America, have attacked this problem in a very practical spirit, and the last-named gentleman has still further developed the theory on the subject, with the result of arriving at practically the same conclusions as Dr. Hopkinson as to the correct basis on which to frame electricity charges.

As far as the author is aware, no one has hitherto made public the results of applying the original Hopkinson method to actual accounts. He therefore proposes to describe modifications of the method, and the results of analysing by them the figures obtained from the central supply station with which he is most conversant, namely, that of the Brighton Corporation.

At the onset he stipulates that the cost of supplying electricity shall be understood to be the sum of all the items necessarily debited to the undertaking's net revenue account, or that it is equal to the amount of revenue the undertaking must earn per annum for it to be considered self-supporting. In the next place, it must be understood that the methods adopted are only really applicable to stations which have got into full working order, and which are not either over-capitalized or much too large for the actual business done, but which can be extended as soon as the increase of demand will warrant same; and in such a business as that of electricity supply, it is essential for commercial reasons to assume the supply is taken by all classes of consumers for at least one year, when estimating the total cost of supplying these classes.

Determination of Standing Costs and Running Costs

If monthly or quarterly statements be made of the total expenses and charges debited to the revenue account of a central supply station, the most careless observer cannot fail to notice how very slightly the total expenditure varies during the different months of the year, although the output or sale of units during the different months may vary as much as threefold.

A comparison of these monthly or quarterly statements during a period when the output has considerably varied, furnishes, in the opinion of the author, the most correct and simple method for determining those portions of the total cost of supplying electricity which vary with the number of units sold, and which are conveniently called "running costs" in contradistinction to the "standing-by costs," and the method by which the cost of supplying any class of consumers can be approximately ascertained.

In the first place it may be observed that, as regards the above divisions of the total expenditure into the two classes of running and standing-by costs, in actual central station practice only the following items can be properly included under the head of *running costs*:—coal, oil, water, and a few other engine stores, besides those repairs to the steam and electricity generating plant which are caused by the continued supply of electricity to consumers.

Under *standing-by costs* must be included all coal and oil used in getting up steam and in keeping the machinery and mains in a position to supply electricity to the consumers at any time, also all other stores used in the station or on the mains, all the wages debited to revenue account, as in practice these do not vary from month to month with the output of electricity, repairs to buildings, mains, meters, and those repairs to plant, etc., which are due to it having to be kept in a position to supply electricity, all rates and taxes, management expenses, insurances, and all provisions for redemption of capital and interest on same, and for the creation of any reserve or depreciation fund it may be decided to form for the purposes of preventing any cessation of the supply at any future time.

Of the above items constituting the running and standing-by costs, the only ones which are not capable of being at once debited to the proper division are the coal, stores, and repairs of plant, but the two first of these can be very fairly divided by the use of the following simple method which its accompanying formula will explain and justify.

Let T represent the total expenditure on these items during one month or period of time when the sale of electricity U is great, and T′ that for another period of preferably the same year when the sale U′ is much less.

Let S be the cost of the two items coals and stores which have to be used during each of the two periods on account of having to get

ready and to stand by, and R the running cost per unit it is desired to determine.

Then by the definition, as $T = S + R \times U$

and $T' = S + R \times U'$

then $T - T' = R \times (U - U')$

$$\text{therefore } R = \frac{T - T'}{U - U'} \text{ and } S = T - R \times U \text{ or } T' - R \times U'$$

or the average cost per unit of continuing to supply electricity during these two periods is the difference of the total expenditures divided by the difference of the sales in the two periods.

With regard to the item of plant repairs due to continued supply, as these repairs are of an accumulative nature, it is advisable to divide the total of all items of repairs obviously due to having to continue generating electricity from the commencement of the supply by the total number of units since supplied, the quotient will be then a fair valuation of the running cost per unit for plant repairs.

To illustrate the above method of apportioning items involved both on account of running and standing-by, the following statement referring to the figures of the Brighton undertaking will be of use:

	The amount spent in coal	Engine Stores	The units sold during these months
In the three months of October, November and December in 1895	£990	£201	366,040
In the three months of May, June and July	365	133	109,662
The differences between the figures are	£625	£68	256,378

Therefore, by the above rule the running cost for coal during these six months was

$$\frac{625 \times 240}{256{,}378} = .584\text{d. per unit}$$

For oil and stores $\dfrac{68 \times 240}{256{,}378} = .063\text{d. per unit}$

and from the total amount spent on running cost repairs, during the four years the central station had been in full working order, the author finds the running cost repairs averaged at the end of 1895 .063d. per unit sold. Then, as the running costs of the remaining six months of 1895 were about the same as the above values, by this method it is possible to arrive at a very fair division into running and standing-by costs of the items on the debtor side of the Revenue Account of 1895.

Division of the Debtor side of the Brighton 1895 Revenue Account into Running and Standing-by Items:

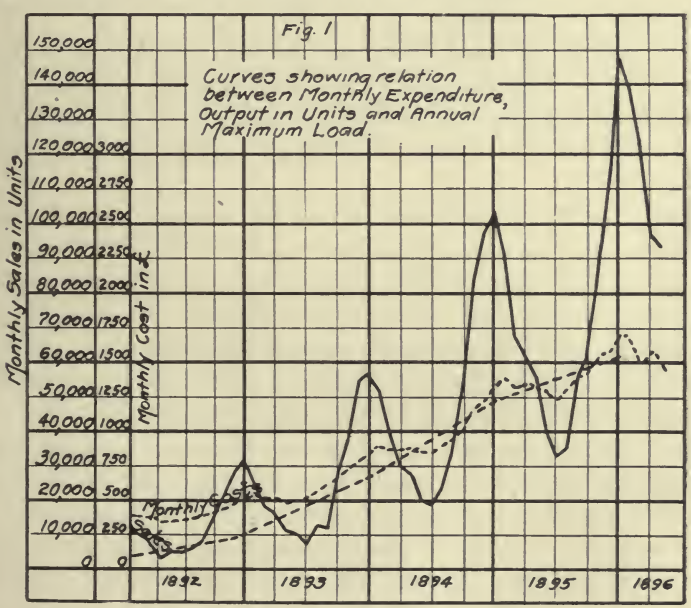
Item	Rate per unit for running costs determined by above method	Total running costs for the 867500 units sold	Total standing-by costs	Total amount spent on the items during 1895
	d.	£	£	£
Coal	.584	2,111	485	2,596
Stores	.063	230	302	532
Repairs to plant	.063	230	147	377
Repairs to buildings	....	....	59	59
Meters	....	....	69	69
Mains	....	....	463	463
Wages	....	....	1,719	1,719
Rates and taxes	....	....	327	327
Management	....	....	1,838	1,838
Insurance	....	....	69	69
Interest & Sinking Fund	....	....	7,777	7,777
	d.	£	£	£
Totals	.71	2,571	13,255	15,826

As the annual maximum load on the station is generally increasing, the mean of the two consecutive years' annual maximum loads is taken to be the demand on the Station, in calculating the standing-by cost per kilowatt; this in 1895 was £17.9 per kilowatt as thus defined.

Study of Monthly Expenditure Curves

The above obtained values for the running and standing-by costs at Brighton in 1895 are closely confirmed by quite a different method to be presently described, based on the analysis of the different years' expenditure curves into the different terms of an equation obtained empirically.

If the total monthly expenditures as above defined from soon after the starting of the undertaking be plotted in the form of a curve, such as the dotted one shown in Fig. 1, and the corresponding sale of units be plotted alongside this, no very obvious connection between the two curves will be discernible, at all events certainly nothing like the uniform price system of charging implies ought to exist. If, however, the maximum annual load taken off the mains be plotted on the same diagram, as shown by the crosses, with a suitable scale, and these points or crosses be connected by straight lines, a very obvious tendency becomes apparent after the first or second year for the monthly total expenditure to follow this line joining the points representing the annual maximum loads and the slight deviations from this line will be found to be roughly proportionally to the monthly sales of electricity.



The author, after studying this monthly expenditure curve of the Brighton Station, which he thinks may claim to be one fairly representative of economically run undertakings, feels convinced that the chief governing factor in determining the monthly expenditure in any Central Station will probably be found to be the maximum annual load which the station has to be prepared to meet every succeeding year, and that after the first year or two, the

total of the standing charges will be found, for all practical purposes, to be fairly proportionate to this maximum annual load.

Classification of Standing Costs

Mr. W. J. Greene, in the paper alluded to, has pointed out that the standing charges ought theoretically to be divided into the three following distinct classes of expenditure:

No. 1. Those due to the preliminary expenses in starting the undertaking, which may be called Basic expenses.

No. 2. Those depending on the cost of connecting the consumers, called Connection costs.

No. 3. Those proportional to the total maximum simultaneous demand of the Consumers on the mains, and conveniently called Demand costs.

With regard to these three groups into which the standing charges may be divided, the author finds that the following is the percentage each of the three classes bore to the total annual expenditure incurred after the Brighton undertaking had been worked four complete years:—

The Basic, or those due to the original unproductive outlay incurred in starting the undertaking, constituted 6.3 per cent. of the total. Connection costs, or those due to the cost of connecting consumers, 11 per cent. The Demand costs, or those due to having to be ready to supply the annual maximum load, 66.4 per cent, and the running costs, or those due to having to continue to run the machinery after it has been started, 16.3 per cent.

The most important point to be noticed in connection with these ratios is that the very small percentage that the running costs bear to the total in such a town as Brighton, viz., only 16.3 per cent, would obviously be very much smaller if coal could be there obtained at say 10s. per ton, the price paid for an equivalent quality in some of the northern and midland towns, and in that case, instead of annual standing charges being about five times the running costs, as they are now at Brighton, they would probably be quite eight and a half times. Hence, *there is obviously the greater necessity for a differential tariff in towns where coal is cheap than where it is dear,* as at Brighton.

In view of the great expense of connecting consumers and of this being practically independent of their demand or consumption,

Mr. Greene strongly advocates the system of making a minimum charge per annum on this account, as well as on account of their demand.

Standing Costs Proportional to Demand

The author's experience, however, tends to prove that the sum total of the three classes of standing-by expenses follow, as a rule, the rising line connecting the annual maximum demands on the mains.

This near proportionality of the standing charges to the plant capacity of a fairly economically run station may be a surprise to many who think, as the author was formerly inclined to, that the cost per kilowatt demanded on the station would diminish rapidly as the station increased in size; it must be remembered, however, that the above rule does not only include the standing charges due to the central station alone, but it includes all expenses due to mains, meters, service lines, etc., and that the statement does not by any means imply that two stations can be as economically run as one of the same capacity as the two.

The above tendency seems capable of explanation after the following considerations:—

That although the original Basic charges become less and less in proportion to the total expenditure, as the undertaking grows larger, other charges of a similar pioneering character continue to be incurred from year to year; such for instance, as those on account of the cost of extending supply mains into new districts, running or building from time to time expensive feeders and sub-stations; increased office and engine house accommodation which are generally built many years before their full capacity is wanted, and moreover this class of expenditure is not generally all incurred simultaneously, but is spread over a great many years after the starting of the undertaking. Also, as regards the connection expenses, as the business grows larger, the average individual demand of the consumers on the station tends to become smaller for the two following reasons:—

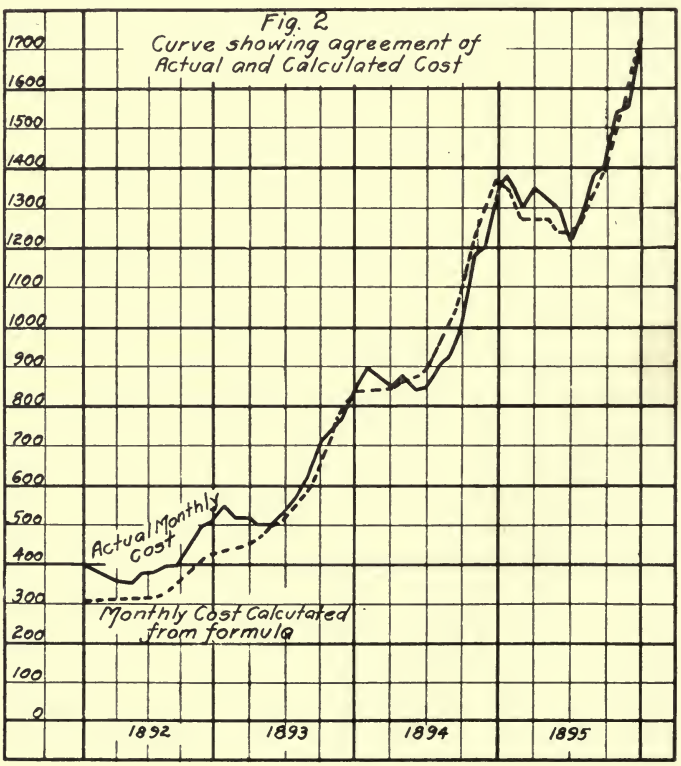
No. 1.—Because the class of consumers generally requiring to be connected soon after the commencement of the undertaking are the larger business premises, shops and hotels, which do not cost for connection so much per kilowatt demanded as do the succeeding classes of smaller shops and private houses.

No. 2.—As the number of consumers supplied increases, a greater variety of classes are included among them, and the diversity of the hours at which they use their maximum loads tends to increase, so that a smaller kilowatt capacity of the plant and mains is thus required than if only one class, such as shops, whose maximum demands would be more simultaneous, were supplied; this and the former cause both obviously must tend to make the connection cost per kilowatt *demanded on the mains* increase with the growth of the supply undertaking.

The above reasons appear to the author quite sufficient to account for the observed near proportionality of the standing charges to the maximum load on the mains of a station in full working order.

Comparison of Calculated Costs and Actual Costs

The other method referred to, which can be made use of in determining what effect the varying output has on the various items



constituting the total cost of supplying electricity, especially with stations that have been running for three or four years, is that of analysing graphically curves of monthly total expenditure, output and maximum demand; although this is more tedious and of more theoretical than practical value, the close agreement between the Brighton actual with the monthly costs calculated from the empirical formula thus obtained is another proof that the cost per unit for running expenses is not now more than .8 of a penny.

The formula from which the dotted line on Fig. 2 is calculated is the one found to most nearly fit the last three years' curves, and is as follows:—

Total monthly expenditure in £

$$= £190 + 1.25 \times D + \frac{\text{Units sold per month}}{300}$$

Where D is the value in kilowatts on the gradually increasing maximum load line of Fig. 1.

From the near agreement of the two analyses of 1895 revenue account of the Brighton undertaking, the author feels justified in assuming that the cost of continuing to run the machinery after it is once in a position to supply has not varied very much from ¾d. per unit during the last three years, and that the annual standing charges can now be taken to be about £17.9 per annual maximum kilowatt taken from the mains.

Apportionment of Standing Charges

The question next arises, how is each consumer's proper proportion of the annual total Standing Charges, as determined in the manner previously described, to be properly apportioned?

Theoretically, it might be said that the standing charges ought to be divided into amounts proportionate to the maximum demand of each consumer, at the day and at the very time the maximum load occurred on the mains each year. This, however, it is obviously impossible to determine in practice, and would not be, moreover, necessarily equitable to the consumers who might or might not have used their maximum demands at the exact moment in question. In practice some arbitrary definitions, more or less equitable, of what constitutes a consumer's call on the plant have to be made. At Brighton, for instance, instead of taking a con-

sumer's maximum demand to be the greatest rate of taking current during the year, it has been considered fairer to the consumer to take the mean of six winter months' readings of a maximum current indicator, which, by its very nature, takes quite ten minutes to fully register the passing current. For the purposes of calculating the cost of supplying any individual consumer, it is then assumed that the mean demand as above defined, bears to the total of all the consumers' demands, the same proportion that the plant and mains necessary to supply this one consumer bears to the total plant, etc., required for all the consumers, therefore a proportion of the total annual standing charges are debited to each consumer in proportion to his mean demand.

In the opinion of the author, this method gives as nearly as possible the fairest division of the standing charges, and it makes substantial allowance for the fact, that the demands of the different consumers do not all coincide in point of time of day. Opportunities are also given for preventing any unusual maximum demand being registered, so as not to penalise the consumers for having parties, etc.

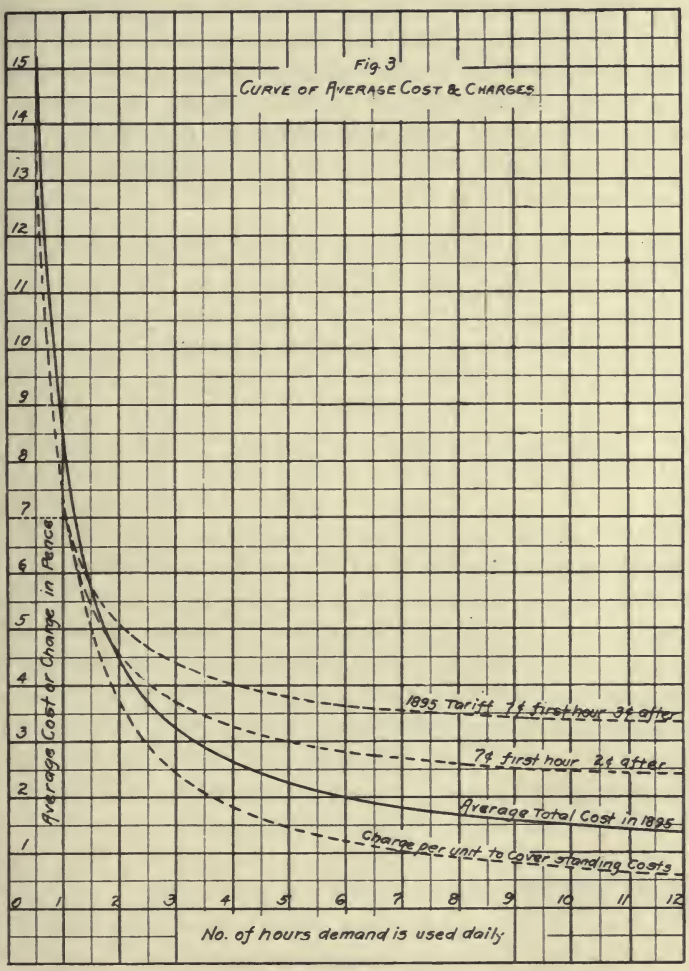
Diversity Factor

Owing to the varying time of day at which the different consumers' heaviest loads are taken from the mains among the fairly large and representative number of consumers at Brighton, the maximum load of the station is now only 66 per cent. of the sum total of the consumers' maximum demands. This want of coincidence in point of time of the consumers' maxima thus means a considerable saving in plant and mains, consequently in the standing charges of the undertaking; therefore the consumers are entitled to the benefit of this, which they get by the Corporation assuming that each kilowatt demanded by a consumer only costs 66 per cent. of the above mentioned £17.9 a year, or £11.8 per annum, which works out to nearly 7¾d. per day per kilowatt demanded by any consumer.

Load Factor—Cost Curves

This figure of 7¾d. per kilowatt, and the previously determined figure of .71d. per unit for running expenses enables the cost of supplying electricity to any consumer in Brighton this year to be very closely ascertained, and from this data the curve of costs, Fig. 3, has been drawn.

The solid line gives the average cost of supplying each unit to a consumer at Brighton in 1895, who used his demand so many hours or fractions of an hour per day on the average throughout the year. The hyperbolic line of dashes shows how rapidly the charge to cover



the standing costs falls as the time of daily use of the demand is lengthened; the total cost curve is obviously obtained from this by adding .71 to it vertically.

Differential Rate

As it was thought impolitic to charge consumers on the true theoretical method of so much per maximum kilowatt demanded,

and so much for the running costs of the units registered by their meters, on the ground that this tariff might possibly have the effect of preventing consumers installing any other lamps than those likely to be constantly used, it was suggested that nearly as fair a charge could be made, by refusing to reduce the highest permissible price per unit consumed, until the individual consumer had paid off all his proportion of the year's standing charges, as determined by the demand indicator, in the manner above described. This system has worked out very well during the last three and a half years, and naturally tends to encourage profitable consumers to use electricity.

From the above calculations it follows, provided all consumers paid 8½d. per unit for the first 365 hours in the year they used their demand, and ¾d. for all units consumed afterwards in that year, the whole of the annual expenditure would be covered, and the Brighton undertaking would be considered in a self-supporting condition. However, there will always be a considerable number of consumers who do not use their demand on the average one hour per day throughout the year, among whom of course must be included a great many of those connected during the year in question, and as the maximum price chargeable at Brighton is fixed at 7d. per unit, it is impossible to charge on this equitable basis. The tariffs adopted for the last three years have been something therefore less fair to the long hour profitable consumer, and by the one now in force each consumer pays 7d. per unit for the first 365 hours in each year he uses his demand and 3d. afterwards. This tariff will doubtless produce sufficient profit during this present year from the units charged at 3d. to people using their demand, say slightly more than 1½ hours per day to justify a reduction in the 3d. units being very soon made to 2d. per unit.

Short Hour Consumers Not Profitable

The small dotted curves show the average price paid by the Brighton consumers on the present and proposed future tariffs according to the average daily number of hours they individually use their demands.

From an inspection of the tariff and cost curves in Fig. 3, it will be seen that loss was incurred in supplying all consumers at Brighton during 1895 who used their demands less than 600 hours per annum. In connection with these unprofitable consumers, it

may be quite reasonably asked how with a given plant and set of mains it can be said that the undertaking can lose money by having to supply one set of short time consumers while it is making a profit on supplying others with the same commodity, or why selling units at 7d. can be less profitable than not selling them at all. The answer is, that in growing stations, as the author premised should alone be considered, the same expensive extensions and the consequent increase of standing costs are necessitated by having to supply the short time consumers as if they were long hour users, although they probably only use their proportion of the plant say three months out of the twelve; thus they not only cause fresh capital to be spent, the interest, etc., on which they cannot pay off themselves, but they necessitate their unpaid share of the standing charges being paid by the better class of consumers, who could have been supplied from the station in the condition it was in at the end of the year without further extensions having to be made for many years to come; therefore, actually this short time class increase the charges to the profitable, and this is surely only another way of stating that there is loss incurred by having to supply them.

Profit and Loss Account

Given the cost of the standing charges per kilowatt demanded by the consumers, the running costs per unit and the individual demands of all the consumers, it must be obvious that it is then possible to make out an annual Profit and Loss Account showing what profit or loss is made from any class of consumers. The author has prepared such a one for the Brighton undertaking in 1895. He has taken the running costs at 8d. per unit, and has divided the classes of consumers into the four following:—

1. Those who were connected during the year, and of which a great many therefore could not naturally have had enough time to pay off their proportion of the standing charges incurred during the year in providing sufficient additional plant for their probable demands.

2. The consumers who did not consume sufficient electricity to be equivalent to the use of their demand 365 hours or one hour per day on the average.

3. Those who were a source of loss to the undertaking owing to their using their demand less than 1½ hours per day, which was about the minimum time necessary on the present tariff to pay off all the cost of supplying them for that period.

Profit and Loss Statement, 1895

Class 1.—Consumers connected during 1895.
Class 2.—Consumers using demand less than 1 hour per day on the average throughout the year.
Class 3.—Consumers using demand from 1 to 1½ hour per day on the average throughout the year.
Class 4.—Consumers using demand over 1½ hour per day on the average throughout the year.

Class	Total of the demand in kilowatts of each class	7d. Units						3d. Units				Net result of supply to each class	
		No. of units charged at 7d.	Standing charges based on 7¾d. per day per kilowatt	Running costs based on .8d. per unit	Total costs	Revenue	Loss	No. of units charged at 3d.	Running costs at .8d. per unit	Revenue	Profit	Loss	Profit
			£	£	£	£	£		£	£	£	£	£
1	175	32,608	2,080	110	2,190	951	1,239	25,682	86	321	235	1,004	.....
2	162	39,006	1,929	130	2,059	1,138	921	.....	.....	.....	.....	921	.....
3	118	45,564	1,410	149	1,559	1,329	230	10,873	45	136	91	139	.....
4	635	254,443	7,540	831	8,371	7,422	949	459,318	1,490	5,741	4,251	.....	3,302
Totals	1,090	371,621	12,959	1,220	14,179	10,840	3,339	495,873	1,621	6,198	4,577	2,064	3,302
											Deduct Losses.....		2,064
											Resultant Annual Net Profit.....		£1,238

4. The profitable class who used their demand more than about 1½ hours per day on the average throughout the year.

From the foregoing profit and loss account it will be seen that in consequence of the highest price allowable being fixed at Brighton at 7d. per unit, it was necessary to charge the longer users of electricity at a substantial profit to recoup the losses incurred in having to supply the unprofitable, although this was nothing approaching the rate of profit that would have been charged to them had all consumers paid the uniform price per unit necessary to produce the same revenue.

Conclusions

The results of the above presumably correct methods of analysis being applied to existing electricity works' accounts appear to so thoroughly confirm Dr. Hopkinson's startling conclusions, and to warrant so many fresh departures from the usual methods of attempting to develop the business of Electricity Supply, that the author sincerely trusts the convention will carefully criticise the principles enunciated, and either frankly combat, refute or accept the following far-reaching conclusions the author has been forced to realise.

1. It is the duty of municipalities to charge a uniform rate of *profit* on the cost of supplying electricity rather than a uniform price to all consumers, and much more so in the case of electricity than with gas, because of the much greater percentage standing charges bear to the total cost in the former than in the latter case.

2. To charge the same amount for the electricity consumed by 100 lamps burning 4 hours a day as that by 400 lamps burning one hour per day is manifestly unjust to the longer user, as only a quarter of the plant and copper are required to produce and supply it as are required by the shorter user.

3. The practice of charging profitable and unprofitable consumers the same price per unit must necessarily have the effect of keeping the average cost and price higher, consequently the supply business smaller, than by charging a uniform rate of *profit* to all consumers, because, having to charge the profitable consumer in order to recoup the loss incurred in supplying the unprofitable must tend to prevent the former using it as liberally as if he had not to pay such a high rate of profit. Therefore electricity can be produced at a lower price on an equitable sliding scale of charges than on a uniform price.

4. The extremely low price at which electricity can be profitably supplied to consumers after they have paid off their proportion of the standing charges much more than compensates for the difficulty of understanding a uniform rate of profit tariff, as shown by the increasing rate of receiving applications for electricity in towns where differential charges and low prices to long users are in vogue.

5. It is in every sense advisable to retain the initial charge per unit at the *highest permissible* figure, and the charge for current after the standing charges are paid for at as *low a figure* as is compatible with making a safe annual net profit; as experience proves that consumers judge their electricity accounts solely on the total amount, and those consumers who are always charged the highest price are naturally the least worth having and the only ones likely to complain of the equal profit system of tariff.

6. It is erroneous to suppose that by increasing the size of the business the loss on supplying the ordinary short hour user will diminish as time goes on; as offices and similar short-time consumers generally light up at dusk, an increased number of such can only aggravate the peakiness of the load curve, and cannot therefore reduce the standing charges per kilowatt demanded, on which the cost of supplying them mostly depends.

7. It is much fairer to the ratepayers to try to limit the supply to consumers who are willing to pay their share of the costs than to have to rapidly extend the supply works in order to take on more unprofitable as well as profitable consumers, or, in other words, it is more justifiable for a municipality to lose the unprofitable consumers by raising the initial price, and to take in their place more profitable ones, than to extend the works directly their capacity is reached.

8. The enormous cost of getting ready to supply electricity, compared to the cost of continuing to supply when ready, can be best realised by remembering that *it costs two and a half times as much to supply a unit to a consumer who uses his lights on the average only one hour per day as it does to another who uses them three hours.*

9. With coal at the price paid in Brighton, the same reduction can be made in the average cost of producing electricity by so arranging the tariff as to improve the load factor 3 per cent as if the coal bill had been reduced 15 per cent. Although the author does not wish it to be understood that he discourages the attempt to save coal, he desires to point out that it is much more worth while trying to improve the load factor than to reduce the coal bill. Since the

differential tariff has been adopted at Brighton, the load factor has improved 50 per cent, showing the improvenent wanted is not difficult to attain. In the Midlands, where coal is half the price paid at Brighton, probably the same reduction in the average total cost of electricity would be made by improving the load factor 3 per cent as if the coal bill had been reduced 30 per cent.

10. The differences in the financial results of central supply stations are more due to the different load factors, and the varying economy in standing by costs, than by any great differences in the amount of running costs.

11. The rapid fall in the cost of supplying electricity as the average time of use increases makes the small householder a much more profitable class to supply, both in his residential and shopping districts, than the residences and shops where the wealthy dwell and deal, owing to the frequent absence from home of this class and the early closing of their shops.

12. One of the most important consequences of the fact that electricity can be profitably supplied from central stations to consumers at the rate of 8½d. per unit for the first 365 hours in each year they use their demand, and for something between ½d. and 1d. (according to the price of coal) for any electricity consumed afterwards in the same year, is that street lighting and that of basements or dark buildings lighted all day long, can be more cheaply done by electricity than by any other form of artificial light, as in these cases, where the use is on the average eleven hours per day, or 4,000 hours per annum, *the inclusive cost for the electricity consumed will not generally exceed* 1½*d. per unit.*

The fact that up to the present only the very fringe of street lighting has been touched by the Electricity Supply undertakings appears to the author a sure sign that Dr. Hopkinson's conclusions have been hitherto ignored by most of the responsible managers, and to again direct and urge them to give their closest attention to them has been the author's object in writing this lengthy paper.

Equitable, Uniform and Competitive Rates

by

HENRY L. DOHERTY

Presented before the
National Electric Light Association
May 1900

(Reprinted from Proceedings of National Electric Light Association, May 1900, pp. 291-321)

INDEX

Equitable, Uniform and Competitive Rates

By H. L. Doherty

1900

Introduction

We probably all agree that the rate question is of vital importance to the development of central-station work. Of the several methods proposed, none are universally satisfactory, even to the managers of stations similarly situated, and many of us are not satisfied with any of them.

The natural laws governing the sale and purchase of electric current do not differ greatly from those of any other commercial business, except in one particular; the average commercial business is at liberty to bargain and sell with each consumer; it is at liberty to discriminate in prices or methods.

Discrimination in Rates

Any company enjoying public grants is apt to be considered as a quasi public corporation, and is amenable to the general laws of this class. Frequent suits have been brought to determine the right of a quasi public corporation to discriminate in rates between various customers, and in almost every instance the court has held that such discrimination was illegal. Numerous decisions would warrant us in considering the illegality of discrimination to be an established fact. The whole question, then, must hinge on what constitutes discrimination. There is probably more legislation in vogue for the control of railroads than for any other class of quasi public corporations, and the Interstate Commerce Commission (a national board of control) permits them to charge different rates per ton for different distances, not proportional to the distance, and also permits them to charge different rates per ton for the same distance for different commodities. This would warrant the belief that we could legally discriminate in our methods of charging between different classes of service and different classes of consumers.

The right to bargain with each customer is a doubtful advantage, and private business houses that are not amenable to legal prevention against discrimination have nearly all abandoned this

policy in favor of a similar policy that is forced upon us legally. In view of the fact that they deal with the same class of people as the customers of the average central station, it is natural to suppose that our eventual policy will be one price to all, regardless of legal coercion.

Comparison with Gas Business

The electric business was started as a competitor to gas. The early promoters of this new method of lighting were naturally inclined to adopt the same methods of charging as then in vogue among their competitors. Without meters, they were compelled to use flat rates. Later, when meters were procurable, they adopted the system used by the gas companies, and have since gradually awakened to the fact that while this system may be suitable to gas business (which is questionable), it is not suitable to the electric business. Much of the experience gained in the gas business is applicable to the electric business, but there are certain distinctive features for which compensation must be allowed. Gas companies can manufacture uniformly for twenty-four hours, being able to store their product cheaply and economically. The distribution of gas does not require any exact degree of pressure regulation. The conductors used are hollow, and the cost does not increase proportionally to the increased conductivity.

I give below some comparative figures, which I think forcibly indicate some of the differences between the electric and gas business, requiring special consideration:

Cost of Storage Capacity, Gas and Electricity

Gas per 1,000 cu. ft.....	$50.00	
Gas per ft.....	.05	
Electric per K. W.-hour	100.00	
Gas per C. P.-hour.....	.0033½	Incandescent gas lamp, 15 candles per ft.
Electric per C. P.-hour..	.10	Arc lighting, 1 Watt per candle.
Gas per C. P.-hour.....	.0166	Open flame, 3 candles per ft.
Electric per C. P. hour..	.312	Incandescent, 3.1 Watts per candle.
Gas per K. W.-hour, developed.....	1.25	Gas engine, 25 cu. ft. per K. W.-hour.
Electric per K. W.-hour, developed.....	125.00	Electric motor, 80 per cent efficiency.
Gas per $1.00 unit of value.....	50.00	$1.00 per 1,000 cubic ft.
Electric per $1.00 unit of value.....	1,000.00	.10 per K. W.-hour.

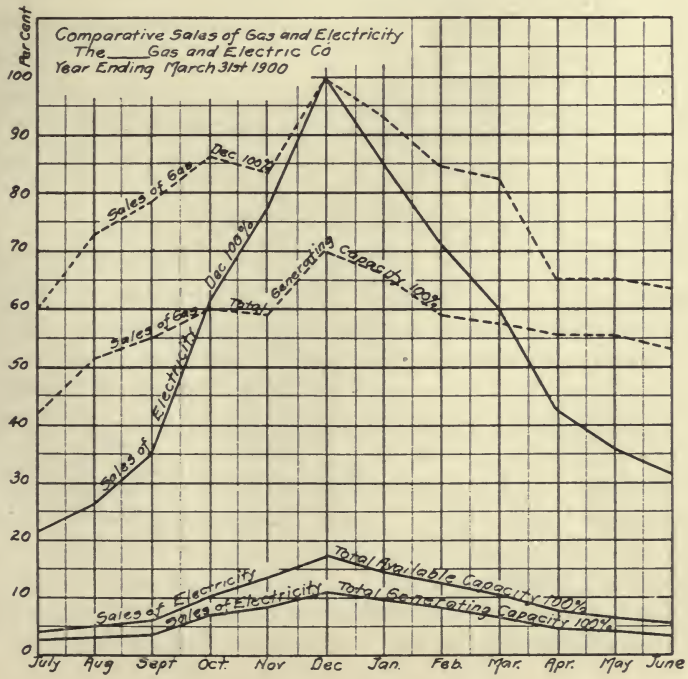
Gas per million B. T. U.	76.97	650 B. T. U. per ft.
Electric per million B. T. U.	29,312.53	778 ft.-lbs. per B. T. U. 3,411.51 B. T. U. per K. W.-hour.
Gas—Efficiency (approximately)	100 per cent.	
Electric—Efficiency (approximately)	56 to 72 per cent.	

Conductors, Gas and Electric

Gas—Size of pipe (cast-iron)	2 in.	4 in.	8 in.	16 in.	30 in.	60 in.
Area—in circular inches	4	16	64	256	900	3,600
Conductivity	1	5.65	32	180	880	4,950
Relative conductivity per circular inch	1	1.4	2	2.75	3.9	5.5
Relative conductivity of electric conductors	1	1	1	1	1	1
Weight of pipe per foot	6	17	40	100	250	900
Relative conductivity per pound	1	2	4.8	10.4	21.2	33.5
Relative conductivity of electric conductors	1	1	1	1	1	1

Load Curves, Gas and Electricity

I also give daily and yearly load curve for the same city for gas and electric service, showing also the percentage "sendout" compared with the generating capacity of the two plants:



Fixed Charges

The central-station business is one composed largely of fixed charges, whose aggregate amount is not appreciably affected by the quantity of current sold. The cost of current delivered on the consumers' premises is more greatly influenced by a high kilowatt consumption compared with the maximum demanded than by any other factor affecting our cost.

Methods of Charging

Tiresome as it may seem, I shall have to consider the better known systems of charging before proceeding further with my argument. I shall confine this discussion to the several distinctive methods of charging now in vogue, and shall not attempt to discuss the numerous variations that have been injected into them to compensate for their lack of ability to meet the objections of the managers adopting them.

The main distinctive systems are as follows:

First—Flat rates.

Second—Uniform meter rates.

Third—Meter rates differing on quantity of consumption.

Fourth—Meter rates with a minimum guarantee.

Fifth—Meter rates different on amount of time maximum capacity of installation is used.

Example: New York system.

Six—Meter rates varied by the amount of time maximum demand is used.

Example: Wright demand system.

Seventh—Meter rates varying according to time of day at which current is used.

Example: General Electric Company two-rate meter.

The first four of these systems do not, I think, have a single prominent advocate. The New York system is only mildly advocated by the users, and they admit that it is inequitable. The two latter systems are advocated by some of the most prominent men in the profession, but their most sincere advocates are those interested in the patents on the appliances which their use demands. I say this without any wish to cast reflection upon the advocates of these systems. If any of us think a thing is good enough to buy, we should certainly think it good enough to advocate, and we should be entirely justified in doing so; but when we, as central station men, consider any of the problems in our business, we naturally feel that a financial interest in any one system is apt to warp the judgment of the one so interested.

Flat Rates

OBJECTIONS

First—They are not suited to all classes of consumers.

Example A—The long-hour consumer pays less than cost.

Example B—The short hour consumer cannot patronize a station of this method of charging, as the cost is apt to exceed that of other means of lighting.

Example C—The cost to the consumer with a big installation and a small maximum demand is prohibitive.

Second—Rigid inspection is required.

Example A—Fraud is possible by increasing the number of lights, by increasing wattage of the lamps used, and by the theft of current for other uses.

Third—The installation is curtailed.

ARGUMENTS IN FAVOR

First—If the rate is high enough, no loss can occur to the station except by fraud.

Second—The system permits of simple office records, and offers little opportunity for disputes between company and consumer.

Third—The income is constant, and can be safely anticipated.

Fourth—The fixed charges of the plant are insured.

Fifth—They require no investment for meters.

Sixth—They permit of accurate calculations of the distributing system.

Seventh—Their legality is not apt to be questioned.

Uniform Meter Rates

OBJECTIONS

First—They are not suited to all consumers.

Example A—The short-hour consumer very probably does not pay the cost he occasions.

Example B—The long-hour consumer can often procure other service more cheaply.

Second—The rapidity with which bills increase in the fall gives rise to dissatisfaction among consumers, which is a menace to the safety of central-station investments.

Third—They are the greatest encouragement to the installation of isolated plants, owing to the fact that the long-hour consumer can manufacture his own current the most cheaply, and it is from this class of consumers that the maximum profit is demanded by this system.

Fourth—As the central station must carry some consumers at a loss, they cannot sell to profitable consumers at a price permitting competition with isolated plants and other means of obtaining light.

Fifth—They encourage heavy peaks and discourage liberal use of current for lighting and other purposes.

Sixth—They require constant arbitrary adjustment of rates.

The second reason given is, I think, of more importance than is generally recognized.

I append chart, showing the number of burning hours in each month in the year, and a careful study of this tabulation shows a remarkable increase in light bills in approaching the season of least natural light:

Table Showing Number of Hours Artificial Light is Needed in Each Month of the Year

Evening from	July	August	September	October	November	December	January	February	March	April	May	June	Total
Dusk to 6 o'clock	...	...	2	33	62	80	65	33	4	...	...	...	279
Dusk to 7 o'clock	...	14	22	62	92	111	96	61	31	4	...	...	493
Dusk to 8 o'clock	...	40	52	93	122	142	127	89	62	28	4	...	759
Dusk to 9 o'clock	13	71	82	124	152	173	158	117	93	58	29	8	1,078
Dusk to 10 o'clock	44	102	112	155	182	204	189	145	124	88	60	38	1,443
Dusk to 11 o'clock	75	133	142	186	212	235	220	173	155	118	91	68	1,808
Dusk to 12 o'clock	116	164	172	217	242	266	251	201	186	148	122	98	2,183
All night	217	307	345	421	473	527	512	411	382	295	242	195	4,327
Morning from													
4 o'clock to dawn	...	16	48	80	110	137	137	93	71	28	2	...	722
5 o'clock to dawn	..	...	18	49	80	106	106	70	40	3	...	...	472
6 o'clock to dawn	...	...	...	18	50	75	75	42	9	...	...	...	269
7 o'clock to dawn	...	...	...	...	20	44	44	14	...	...	...	...	122

ARGUMENTS IN FAVOR

First—Next to flat rates they require the least investment for measuring apparatus, and a more simple system of office records than the two-rate system.

Second—Less attention is required than for any of the two-rate systems.

Third—The legality of this system is not apt to be questioned.

Meter Rates Based on Quantity of Consumption

OBJECTIONS

First—They do not properly discriminate between customers of unequal worth.

Second—A lesser consumption often costs more than a slightly greater consumption.

Third—Their legality is questionable.

Fourth—In addition to these objections, they have all the objections of the uniform meter rate system, except perhaps in a slighter degree.

Fifth—They are generally based on nothing accurate, and represent only the whim of the maker.

ARGUMENTS IN FAVOR

First—They require less frequent arbitrary reductions in rate than the uniform meter rate system.

Second—Less attention is required than for any of the two-rate systems.

Meter Rates with a Minimum Charge

OBJECTIONS

First—The minimum charge is generally based on illegal grounds, and does not represent minimum cost to station for "readiness to serve."

Second—They do not properly discriminate between consumers of unequal worth.

ARGUMENTS IN FAVOR

First—The company is partially or wholly insured against loss on short-hour consumers.

Second—Insurance against loss permits them to sell to their profitable consumers at a more equitable rate.

Meter Rates Based on Quantity of Time Maximum Capacity of Installation Is Used

This is what I term the New York system, and is one where the consumer pays at a high rate for the first one, two or three hours' use of his total capacity, all additional current being given him at a much lower rate.

OBJECTIONS

First—They are not suited to all classes of consumers.

Example A—The short-hour consumer pays less than the cost of service.

Example B—They unjustly discriminate against the consumer with a large installation and a small demand.

Example C—The short-hour consumers pay the same rate per kilowatt until they reach a certain consumption, and yet it is axiomatic that the consumer that uses current for nearly all of the required time is much more valuable than the consumer that uses current for only a small portion of the time.

Second—Frequent and rigid inspection is required.

Third—Fraud is encouraged.

Fourth—A liberal installation is discouraged.

Fifth—The necessity for arbitrary reductions in rates is not entirely eliminated.

Sixth—The legality is questionable.

ARGUMENTS IN FAVOR

First—They encourage longer-hour consumption of the long-hour consumers.

Second—They require a less investment for measuring apparatus than any other two-rate system.

Third—Less attention is required than for the two-rate or Wright demand system.

Meter Rates Varied by Total Time Maximum Demand Is Used

Or what is generally known as Wright demand system.

OBJECTIONS

First—It is not suited to all classes of consumers.

Example A—Short-hour consumers do not pay full cost of service.

Example B—Long-hour consumers must be made to pay more than cost of service and proportional amount of profit to compensate for loss on short-hour consumers.

Second—A liberal installation is apt to be discouraged.

Third—Liberal consumption is also apt to be discouraged for the sake of keeping down maximum demand.

Fourth—Consumption is curtailed to lower demand registrations at seasons when peak is not undesirable.

Fifth—This system is apt to occasion the greatest possible fluctuation of peaks for different months in the year, while a uniform peak is desirable.

Sixth—The charge bears no exact relationship to the cost.

Seventh—Errors in reading cannot be rectified.

Eighth—Accuracy of readings cannot be demonstrated.

Ninth—The equipment is expensive.

Tenth—It is the most complicated of all two-rate systems and is the least apt to be fully understood by the consumer, and, therefore, not apt to inspire the consumer with confidence.

Eleventh—Cost of inspection is increased.

Twelfth—It is possible for the company to be defrauded by collusion between the inspector and the consumer.

Thirteenth—It does not eliminate the necessity for arbitrary reduction in rates.

Fourteenth—Its legality is questionable.

Arguments in Favor

First—In general the charge to the consumer more closely approaches the cost he occasions than any of the other systems enumerated.

Second—It permits concessions to valuable consumers with some degree of accuracy.

Meter Rates Varying According to Time of Day at Which Current Is Used

Example—General Electric Company's two-rate meter.

Objections

First—It is not suited to all consumers.

Example A—A short-hour consumer does not pay as much as the service costs.

Example B—It discourages the use of light at a time when such use is desirable.

Second—It is apt to inspire but little confidence in the consumer.

Third—It is expensive to buy and to maintain.

Fourth—It charges the most for current at a time when the cost is least.

Fifth—It does not properly discriminate between short-hour and long-hour consumption.

Sixth—It requires frequent settings for different periods of the year.

Seventh—Its legality is questionable.

Arguments in Favor

First—It encourages consumption at some of the desirable hours.

Second—Errors in reading can be rectified and their accuracy demonstrated to the consumer.

Discussion of Above Rate Systems

None of these systems will show any exact relationship between the cost to the central station and the charge to the consumer. Charging on basis of maximum capacity installed is so inequitable, that I hardly feel called upon to defend my objections to it.

The Wright demand system has certainly proved a step in the right direction, but the fact that of even its warmest advocates no two agree exactly as to how it should be used, seems almost conclusive evidence that it is not by any means perfect.

The two-rate meter is also an important change from former methods, but it is almost ridiculous to sell current at a lesser price when it costs us most and at a greater price when it costs us least. Assuming that commercial expediency warrants this peculiar condition, there are other and more serious objections which limit its use to special cases.

Importance of Proper Rates

During the past two years I have made a careful physical and financial examination of twelve stations, in cities varying in size from 12,000 to 250,000 population; during the same period I have made a similar but less thorough examination of eight central stations, in cities varying in size from 4,000 to 600,000. In every case it seemed to me that a good system of rates was more badly needed than anything else. None of the stations had uniform rates; four of them had more than fifty per cent of their consumers on special rates. None of the systems outlined above were universally applicable to all the central stations examined.

Paradoxical as it may seem, the stations realizing the lowest income per kilowatt-hour were generally making the largest return on their total investment. As all of these stations showed the greatest kilowatt output compared with their total generating capacity, I have concluded that their increased earnings were entirely due to a greater use of light, which is very apt to follow the introduction of low rates.

In addition to the examination of other stations, I have had occasion to fix rates for three central stations during the past year. Of the many trying problems that are apt to confront a central-station manager, I am free to confess that I felt less ability to deal with the rate question than with any other that might have come up. I have tried to study the rate question, simply to be able to

act intelligently when again forced to decide on the rearrangement of rates for an existing central station or on the arrangement of rates for a new central station.

Factors Governing Rate Making

From a commercial standpoint, we are governed by two general laws:

First—We must not sell at less than cost to us.

Second—We must sell at no greater cost to the consumer that that at which the same service or a suitable substitute can be obtained by other means.

This gives us certain limitations upon which to base our methods of charging.

First—Our minimum must be not less than the cost to us; and

Second—Our maximum must be not greater than the worth to the consumer.

Other factors that may be considered are these:

First—If we must provide for a heavy peak for one month or one night in the year, it is desirable to have as nearly as possible the same demand throughout the year (assuming, of course, the same characteristic load curve), and any system tending to depress this peak at other seasons than our maximum load, is unwise and objectionable.

Second—Any system that tends to depress this curve at any other point than the peak, is unwise and objectionable.

Third—If we lose on one customer, we must make it up on another customer.

Fourth—If we lose on some customers, we cannot sell so cheaply to others, and are at a disadvantage when sharp competition is met.

Fifth—If we lose on one consumer for a portion of a year, we cannot realize the same yearly profit without charging a correspondingly higher profit for the rest of the year.

Sixth—There are certain short-hour consumers that are a loss to the central stations' operation at even twenty cents per kilowatt-hour.

Seventh—The variations in cost of lighting to the consumer during different seasons of the year should not be greater than the variations in cost to us.

Eighth—Legal restrictions in central-station operations will increase rather than diminish.

Ninth—It is desirable that our methods of charging should permit of favorable comparison with other means of illumination, and especially with isolated plants.

Tenth—Under an ordinary meter-rate system a consumer that has two means of illumination is apt to use electricity for short-hour consumption and other means for long-hour consumption.

Eleventh—We are more interested in knowing what our consumers' maximum demand is going to be than in knowing what it has been.

Competition

As one of the chief factors in determining the proper methods of charging is to meet competition, a short consideration of this subject is not out of place. It is probably necessary to consider only the sources of competition named below.

I give the first three of them in the order that I consider to be their future importance:

First—Natural light.
Second—Isolated plants.
Third—Mineral oil.
Fourth—Gas.

I do not attempt to place gas in any order of importance, as its future for lighting is largely problematic, and should I give the possibilities that I see for this agent, it might lead the discussion from the real merits of the subject of my paper. I will consider it only in the sense of its present development.

Competition by Natural Light

The competition from natural light is seldom considered, in spite of the fact that in many instances artificial light is cheaper and more satisfactory than natural light. The most frantic efforts in architecture are often made to obtain natural light and ventilation, frequently at the sacrifice of room and economy in building. I believe many of our modern buildings could be artificially lighted and ventilated at less cost than the sacrifice of room often requires. Natural light is not always to be preferred to artificial light. I have often closed my shade while in my office in New York, and have resorted to artificial light in preference to the reflected light from the glazed wall on the opposite side of the court, which is at times extremely irregular, owing to the sun being momentarily obscured by clouds.

The primary reason for architecture that yields artificial light is often an effort for ventilation, which can always be more satisfactorily furnished by artificial means. The manager of a large industrial plant told me that to his surprise the cost of production had been materially lessened by working the factory double time. The cost of artificial light had proved to be considerably less than expected and very much less than other savings effected.

Competition by Isolated Plants

Isolated plants have proved active competitors and a thorn in the flesh for more reasons than one. Of all forms of competition I

like this one least. Bad methods of charging have cultivated the isolated plant to an appalling extent. Inability accurately to determine cost of service, backed by threats of isolated plants from consumers, has cost the central stations of the country thousands of dollars. An isolated plant generally robs the station, not only of a large consumer, but of a long-hour customer, and hence a profitable one.

In reported costs of current from isolated plants, nothing is ever allowed for interest, depreciation and ground rent, and seldom is anything allowed for repairs, risk and wages. The installation of isolated plants can generally be forestalled, but competition from oil and gas cannot be entirely eliminated. Many buildings have boilers already installed for heating, and they feel that the cost of operating a dymano will not be much greater. They sometimes forget that heat is wanted but a few months in the year, and is objectionable for the rest of the year; that in the heating season heat is wanted most in the morning when no light is wanted, and least in the evening when most light is wanted.

Competition from isolated plants requires the central stations most careful consideration. The installation of one isolated plant is apt to encourage the installation of others, and isolated plants often grow into competing central stations, and in making new plans for methods of charging we should consider competition from isolated plants more than from gas and oil.

There are certain classes of short-hour consumers that the central station cannot possibly hope to supply at a profit. If supplied at a loss, other customers must pay this.

Competition by Gas

Aggressive competition with gas is apt only to precipitate an active war which will be harmful to both companies. Those who use electricity under ordinary methods of charging and also use oil or gas, generally use the electricity for intermittent and short-hour use and the other means for constant and long-hour use.

A method of charging which will reverse this order is what is wanted. Better let the gas company supply the consumer you cannot supply profitably, and aim to get in return a long-hour consumer that you can supply profitably.

Acetylene gas has been given no attention, although it may demand careful consideration later. It was demonstrated six years

ago that acetylene could be marketed at a competitive price with gas and electricity, but up to date there seems to have been more attention paid to the marketing of the stock and bonds than to the commodity.

Elements Essential for Satisfactory Rate System

The details of any satisfactory rate system must

First—Prevent fraud.
Second—Not unnecessarily complicate office records.
Third—Be easily understood by the consumer.
Fourth—Be competent without objectionable inspections, which reflect on the honesty of the consumer.
Fifth—Encourage a liberal use of current compared with maximum demand.
Sixth—Inspire the confidence of the consumer in its accuracy.

If it calls for any special measuring or recording instruments they must meet the following conditions:

First—They must be inexpensive to purchase and install.
Second—They must be durable and reliable.
Third—They must require minimum attention.
Fourth—Chances for errors should be as little as possible, and errors in their action or reading should be capable of correction, with ability to demonstrate this to the consumer.

Study of Data from Existing Central Stations

Owing to lack of time, I have read comparatively little of the literature on the rate question. To avoid repetition, which unnecessarily consumes the time of a convention like this, it is highly important that all published literature on any particular subject should be thoroughly read before attempting to add to it. I have been the victim of circumstances in gathering data on which to base my arguments. I intended to take the average results of many plants to determine cost of installation and operating expenses, but the reports showed such a marked variation that they could not be intelligently used without further investigation. I obtained practically no information that could be intelligently used in a paper of this sort. I did, however, obtain much information that proved interesting to me, and information that I think will also interest others. In general, the cost of the plants appeared to range between $200 and $400 per kilowatt capacity, sometimes going to $1,000 per kilowatt capacity. The percentage demand per connected load seemed to vary from twenty-eight per cent to eighty per cent. A fair estimate would seem to be about thirty-five per cent on meter

basis and seventy-five per cent on flat-rate basis. Consumption per lamp per year seemed to be very largely influenced by local conditions and the cost of current. It is reasonable to suppose that the average consumer increases or curtails his consumption more from a financial standpoint than from a standard of light. He fixes his mind on the sum he is willing to pay, and if his bills exceed this amount, he decreases his consumption.

Of the central stations reporting the higher the cost of current the shorter the use of the connected load, reports varied from 10,646 watts per year per lamp wired up to a figure incredibly high as compared with plants that have come under my immediate supervision. From eighteen to twenty-five kilowatt-hours per year per lamp wired up can be taken as a fair average for western cities. Compared with population, lamps wired up varied from one and one-half lamps per capita to one-fifth of one lamp per capita. Income per capita varied from fifty cents to $3.50 per capita. Income compared with investment varied from ten per cent to forty per cent. Difference between station output and current sold was seldom attainable, and plants reporting on this point generally showed losses that would cause a gas manager to have violent spasms. One alternating-current station reports an all-year efficiency of lines, meters and transformers of over seventy per cent, and a monthly efficiency for December and January of over eighty per cent. Only one station separates difference between station meter registration and consumers' registration into "accountable" and "unaccountable loss." From the gross difference they subtract transformer iron loss and meter shunt loss, and the difference is termed by them "unaccounted for," and is represented by their C^2R loss, faulty registration of meters, theft of current, and general sources of "unaccounted for."

In the reported costs of operation, some other interesting figures were noted. In general, the extreme variations could only be explained by different methods of accounting. Abundant evidence was to be had that the central-station business of the country is seriously in need of good and uniform accounting. In every instance the cost for boiler fuel was such a small portion of total expense as to lead me to believe that we have heretofore given this expense undue consideration. Cost of lamp renewals in different stations varied as much as the lengths of different pieces of string. Some stations reported cost of lamp renewals at almost a negligible figure. Two stations reported cost of lamp renewals at approxi-

mately the cost of boiler fuel. Assuming cost of lamps at eighteen cents each and a life of 600 hours, the expense is six-tenths of a cent per kilowatt-hour. This would be equivalent to cost of boiler fuel if six pounds of coal costing two dollars per ton were used per kilowatt-hour generated. The importance of this item of expense seldom seemed to appeal to the central-station manager, as the cost where shown on a kilowatt basis was generally figured on total output of station, which included current sold for power and arc lighting. One station has a much larger output in kilowatt-hours for power purposes than for incandescent lighting, and yet has but one-fourth of the generating capacity, both being taxed at their peak to the utmost.

"Readiness to Serve" Costs

The basic reason for meter rates based on quantity of consumption is the mistaken idea that the larger the consumption, the less the cost to the station. The basic reason for the New York and Wright demand system is the idea that the larger the consumption, the less is the corresponding cost to serve. A certain expense is incurred for "readiness to serve" and an increased consumption does not occasion a corresponding increase in expenses. Now, if our cost is on this basis, and we want a system of charging that will correspond to the cost, why should we not make our rates on this same basis? Why should we not charge them at least our cost for readiness to serve?

Our expenses for "readiness to serve" are fixed by:

First—The number of consumers.
Second—The number of meters.
Third—The maximum current demanded.

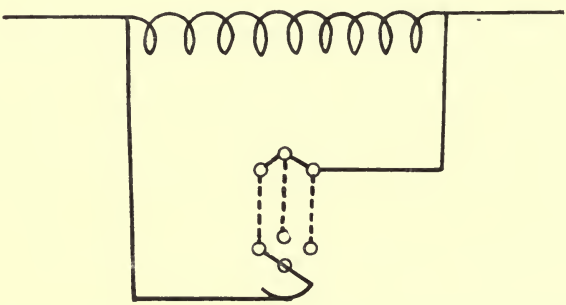
If our cost is the result of these factors, why should we not base our charges on them? This seems to me the most natural and logical course. It corresponds to the cost for service from isolated plants, for such an installation occasions:

First—A certain cost for each plant, regardless of size.
Second—An additional cost, based on capacity demanded.
Third—An additional cost per kilowatt-hour generated.

Method of Assessing Readiness to Serve Charges

If we are going to make a consumer pay for readiness to serve his maximum demand, how shall it be fixed or determined? Should a consumer pay for his maximum capacity or his maximum demand? If he is made to pay for his maximum capacity it will tend to curtail

his installation, and thus probably lessen his consumption, and it also puts a premium on fraud, demanding expensive and objectionable inspections. Shall we take his maximum demand for the year or for the month? The central station must provide for his maximum yearly demand, and it seems to me conclusive that it is his maximum yearly demand he should pay for. Shall we make him pay for what he has demanded or for what he will demand? If we assume that a central station has but one consumer, and he provides an installation which will translate 400 kilowatts, we can hardly afford to let him pay for what he has demanded, but must make him pay the fixed charges for what he may demand, as this is what we have been compelled to provide. If we make him pay for only what he has demanded, and this is not equal to what he may demand, we must charge him a correspondingly higher rate for current, and this charge cannot be intelligently fixed in advance. I propose that



we charge consumers at our cost for readiness to serve, allowing them to contract for whatever capacity they choose, limiting the capacity by suitable means; each contract to run a year and consumer allowed to increase his capacity at will, but not lessen it, except at the end of a year.

The following means have occurred to me for limiting his demand:

First—Fusing to capacity demanded.

Second—The use of a circuit-breaker in place of the fuse.

Third—An interrupter causing the lights to wink when capacity paid for is exceeded.

Fusing, to be satisfactory, should provide for a number of relay fuses connected on a multi-point switch, permitting the customer to throw on another fuse in case he should unconsciously exceed his capacity. An automatic electric bell or vibrator could be used to

notify him that he is burning in excess of his capacity. If desired, a device as diagramed below could be used on alternating currents.

A circuit-breaker can be used in place of the fuse if desired.

For direct current, a resistance can be used in place of the reactance coil. An interrupter can be used on alternating currents, with movable coil or movable core, which will vary the electromotive force if the maximum demanded is exceeded. Numerous simple and satisfactory appliances can be provided to prevent the maximum demand being exceeded.

I would fix the charge for readiness to serve by the minimum cost to the station of all fixed charges and fixed expenses. I would proportion it on the basis of: (a) consumer, (b) meters, (c) maximum demanded.

Analysis of Costs of a Central Station

I give below (page 74) an analysis of the results in one station for year ending May 1, 1900. The total expenses are in first column; division of fixed and operating expenses in columns 2 and 3; a percentage division of fixed charges in columns 4, 5 and 6, and their corresponding values in columns 7, 8 and 9. Taxes, interest and depreciation are obtained by estimates. The station has grown on the instalment plan, and the investment cannot be accurately determined. I have, therefore, estimated worth of station as follows to obtain my fixed charges:

Real estate	$5,000 @ 5% app.		$250 00
Building	6,000 @ 5% dep.		300 00
Boilers, heaters and pumps	12,000 @ 8%		960 00
Engines and condensers	15,000 @ 8%		1,200 00
Generators	12,000 @ 8%		960 00
Switchboard	3,000 @ 10%		300 00
800 poles set cross-armed	12,000 @ 15%		1,800 00
60,000 pounds wire @ 18c	10,800 @2½%		260 00
Stringing wire	3,000		
Transformers	7,500 @ 8%		600 00
1,000 service connections @ $5	5,000 @ 10%		500 00
Lightning arresters and incidentals	3,000 @ 10%		300 00
Engineering and supervising	6,000		
Legal expenses and rights	3,000		
Interest while building	6,000		
925 meters, $15	13,875 @ 10%		1,387 50
18,000 lamps, 17c	3,060		
	$126,230	6.62%	$8,317 50
Taxes @ 2% of 50%			1,262 30
Interest			6,311 50
			$15,891 30

INCOME AND SALES

$38,480.18. 307,389 K. W.-hours sold. Average price, $0.12518.

Connected up,

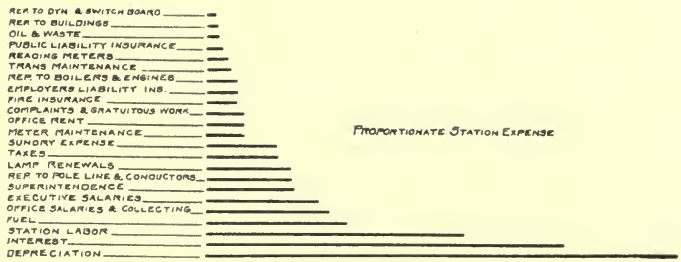
900 consumers. 925 meters. 18,000 lamps.

Consumption,

341.4 K. W. per consumer. 332.1 per meter. 17.06 per lamp.

I have assumed that the aggregate connections would equal two-thirds of the lamps wired up.

As a matter of interest, I give a graphic chart showing the corresponding value of these various expense items.



This system of charging will be immediately put in use at one central station with which I am connected, but the conditions are so unusual that you would not be particularly interested in the plans adopted. I am also seriously considering the advisability of putting this system in use in another station with which I am connected. I am afraid a charge of practically ten dollars per consumer will prove excessive, and have therefore fixed on an arbitrary charge of three dollars per consumer, and have raised my demand charge from $1.34 per lamp to $1.50 per lamp. I give you below a table showing the cost per lamp for various sized installations, based on charge for readiness to serve of three dollars per consumer per year; three dollars per meter per year; $1.50 per lamp demanded per year; and five cents per kilowatt for current, on basis of consumption of previous year, being 25.583 kilowatt consumption per lamp of estimated capacity demanded:

Meters installed	Lamps demanded, being two-thirds capacity installed	Yearly fixed charge	Yearly fixed charge per lamp demanded	Monthly fixed charge per lamp demanded	Yearly charge per lamp demanded, including current at five cents per K. W.-hour	Average monthly charge per lamp demanded, including current at five cents per K. W.-hour
1	1	$7.50	7.50	.625	8.78	.731
1	2	9.00	4.50	.375	5.78	.461
1	3	10.50	3.50	.291	4.78	.398
1	4	12.00	3.00	.25	4.28	.356
1	5	13.50	2.70	.225	3.98	.331
1	6	15.00	2.50	.208	3.78	.315
1	7	16.50	2.357	.196	3.636	.303
1	8	18.00	2.25	.187	3.53	.296
1	9	19.50	2.155	.179	3.435	.286
1	10	21.00	2.10	.183	3.38	.281
1	12	24.00	2.00	.166	3.28	.273
1	15	28.50	1.90	.158	3.18	.265
1	20	36.00	1.80	.15	3.08	.256
1	30	51.00	1.70	.141	2.98	.248
1	40	66.00	1.65	.137	2.93	.244
1	50	81.00	1.62	.135	2.90	.241
1	60	96.00	1.60	.133	2.88	.240
1	70	111.00	1.585	.132	2.864	.238
1	80	126.00	1.575	.131	2.854	.238
1	90	141.00	1.566	.130	2.845	.237
1	100	156.00	1.56	.130	2.84	.237

I give below a table showing cost per kilowatt for various yearly load factors from a quarter of an hour to twenty-four hours per day,

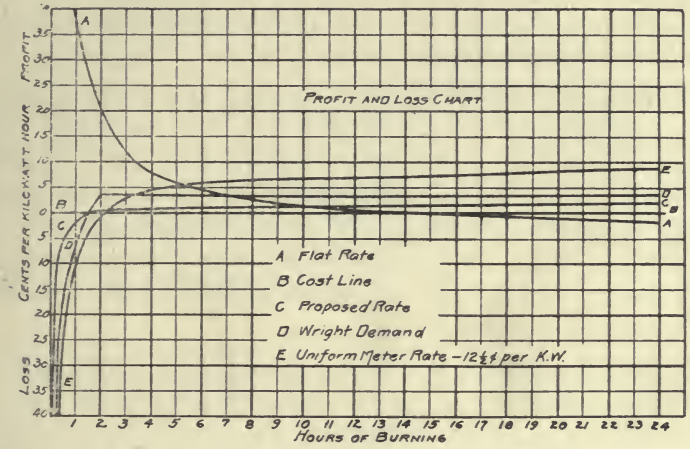
Hours per day of using demand of station	K. W. output per year	Fixed expense per K. W. hour output	Total cost per K. W. hour output including operating expense	Receipts per K. W.-hour by proposed rate, $3.00 per service, $3.00 per meter, $1.50 per lamp and five cents per K. W.-hour	Receipts per K. W.-hour by Wright Demand system; sixteen cents first two hours, six cents after	Receipts per K. W. hour by flat rate of $12 per year
		Cents	Cents	Cents	Cents	Cents
¼	36,500	76.26	79.39	69.3	16.	262.73
½	73,000	38.13	41.25	37.1	16.	131.8
¾	109,000	25.56	28.69	26.4	16.	90.9
1	146,000	19.06	22.19	21.0	16.	65.9
2	292,000	9.53	12.66	13.0	16.	32.9
3	438,000	6.35	9.48	10.3	12.66	21.9
4	584,000	4.76	7.89	9.	11.0	16.45
5	730,000	3.81	6.94	8.2	10.0	13.15
6	876,000	3.17	6.30	7.66	9.33	10.95
7	1,022,000	2.72	5.85	7.3	8.85	9.41
8	1,168,000	2.38	5.49	7.	8.55	8.22
10	1,460,000	1.91	5.04	6.6	8.00	6.59
12	1,752,000	1.59	4.72	6.33	7.66	5.48
16	2,336,000	1.19	4.32	6.0	7.25	4.11
20	2,920,000	.95	4.09	5.8	7.00	3.28
24	3,504,000	.79	3.92	5.67	6.83	2.74

	Total expense	Expenses proportional to K. W. output	Minimum expense for readiness to serve	Percentage division			Value		
				Per consumer	Per meter	Per K. W. capacity	Per consumer	Per meter	Per K. W. capacity
				Per cent	Per cent	Per cent			
1. Fuel	$2478.00	$2478.00							
2. Oil and waste	176.00	88.00	$88.00			100			$88.00
3. Repairs—Boilers and engines	493.00	393.00	100.00			100			100.00
4. Repairs—Dynamos and switchboard	88.00	88.00							
5. Repairs—Buildings and property	132.00	32.00	100.00	50		50	$50.00		50.00
6. Station labor	4518.00	1338.00	3180.00	50		50	1590.00		1590.00
7. Repairs—Pole lines and conductors	1500.00	500.00	1000.00	50		50	500.00		500.00
8. Transformer maintenance	400.00	200.00	200.00			100			200.00
9. Meter maintenance	640.00	400.00	240.00		100			$240.00	
10. Reading meters	336.00		336.00		100			336.00	
11. Lamp repairs and renewals	1500.00	1500.00							
12. Complaints and gratuitous work	600.00	600.00							
13. Office salaries and collecting	2150.00	650.00	1500.00	50		50	750.00		750.00
14. Office rent	600.00		600.00	50		50	300.00		300.00
15. Stationery, postage and sundry expenses	1200.00	600.00	600.00	50		50	300.00		300.00
16. Fire insurance	500.00		500.00	50		50	250.00		250.00
17. Employees' liability insurance	500.00	250.00	250.00	50		50	125.00		125.00
18. Public liability insurance	250.00		250.00	50		50	125.00		125.00
19. Superintendence	1500.00	500.00	1000.00	50		50	500.00		500.00
20. Executive salaries	2000.00		2000.00	50		50	1000.00		1000.00
21. Taxes	1262.27		1262.27	25	*	75	280.88	138.75	842.64
22. Interest	6313.99		6313.99	25	*	75	1405.06	693.75	4215.18
23. Depreciation	8317.50		8317.50	25	*	75	1732.50	1387.50	5197.50
24. Profit	1025.42	1025.42							
	$38480.18	$10642.42	$27837.76				$8908.44	$2796.00	$16133.32

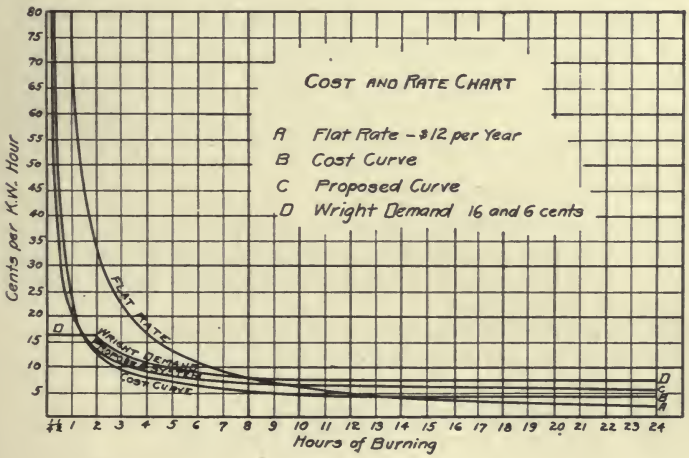
Expense per consumer	$9.898
Expense per meter	3.022
Expense per lamp wired up	0.8963
Expense per lamp demanded on station	2.0166
Expense per lamp demanded by consumers	1.3444
Expense per K. W.-hour sold	0.03475

and the corresponding amount charged consumers under different rate systems. The average receipts for current were .12518 per kilowatt-hour, which, if plotted on this curve, would simply be a straight line from the vertical axis parallel with the horizontal axis at the altitude .12518 cents.

This gives us a profit-and-loss curve as illustrated.



I also give graphic load chart of these same data.



Discussion of Readiness to Serve Rate System

Now I expect to be told that

First—I shall drive away consumers.
Second—That I shall depress the peak.
Third—That the people will not favor the change.

I answer to the first of these objections: (a) that certain customers will be driven away, but they will be the unprofitable ones; (b) that enough of our present unprofitable ones will remain with us

and will pay what their service costs; (c) that many of our present unprofitable consumers will abandon the use of gas and oil for long-hour consumption; (d) that many other customers will be attracted by our low kilowatt rate.

To the second objection: (a) I will admit that I will depress the yearly load peak for a given number of consumers, which I claim will be an advantage rather than a detriment; it will reduce interruptions of service, better our regulation, and decrease our line and transformer losses; (b) but it will encourage a more uniform load peak throughout the year, lessen the investment for meters, and increase the accuracy of their registration by enabling size installed to be intelligently selected.

Your third objection is a matter of education, and I ask (a) if you expect a reduction in your telephone bill if you do not use it for a month? (b) is not this system the natural step to take in changing from flat rates? (c) is the consumer whose bill is reduced apt to object to the change? (d) can you afford to supply the consumer whose bill is increased at less than his schedule charge? (e) are not all objections to this proposed plan due to having improperly educated the public in the past? If you break your leg, you expect the surgeon to cause some pain in setting it, and this pain is chargeable to the accident and not to the surgeon.

I claim for this system:

First—Greater uniformity.

Second—A tendency to produce a better yearly load and better daily load.

Third—An encouragement of long-hour lighting and the use of current for other purposes than lighting.

Fourth—Ability to meet competition of isolated plants.

Fifth—A weeding out of unprofitable business.

Sixth—Better satisfaction to consumers.

Seventh—A lessening of cost of production.

Eighth—A lessening of cost to consumer per kilowatt.

Ninth—Ability to dispense with high-priced, trouble-breeding, rate clerks.

Tenth—Ability to give better regulation.

Eleventh—A lessening of difference between registration of station and consumers' meters.

If desired, a clock arrangement can be used to throw a heavy conductor in series with the demand meter, to encourage heavy use of current at desirable hours of the day.

A deduction for power users can be made from the kilowatt rate for incandescent-lighting current, to compensate for lamp re-

newals and regulation, and thus all classes of consumers can be supplied at a uniform rate.

Many isolated plants are installed simply to use idle capital. A trust fund could be created, and any customers wishing to provide the investment included in the charge for "readiness to serve" could be accommodated. I would not object to a deposit large enough to pay their entire charge for readiness to serve, allowing them the same rate on their money as paid on the bonds. A fund of this sort would do much to silence their objections, even though they should not take advantage of it.

Conclusion

The opportunities for development in the central-station business are simply unlimited. The instances are very rare where a properly equipped central station cannot profitably sell current at less than the cost of production in an independent plant. There is no reason why we should confine ourselves to supplying small powers. Nothing should be too big for us to wrestle with. Many gas companies to-day sell more gas for fuel than for lighting, and the supply of power to the electric business should be what the supply of fuel is to the gas business.

If the individual aggregate demand of your consumers is greatly in excess of your maximum demand, I see no reason why your charge to them for readiness to serve should not exceed the cost, provided rates yielding a profit should prove profitable to the central station in the long run.

The lower the rate at which we can give consumers current, the greater our opportunities for extending its use and finding new uses for it. There is a good deal of human nature portrayed in the story of the salesman who told his rural customer that a certain stove would save half the fuel, to which he replied: "I guess I will take two of them and save all of it." Better have several thousand customers planning means to use additional current, and thus diminish their kilowatt cost, than to attempt to do all of this planning yourself and then have to convince them of the wisdom of your ideas.

Fan work, ventilation, refrigeration, pumping, decoration, sign lighting and miscellaneous power work can be enormously developed by a low rate. As you decrease your rate, your consumers decrease their vigilance of consumption. A low rate will tend to

put many basement, hall and bathroom lights in constant use. Many people are too lazy to even "press the button."

Our salvation from many evils is to have the public understand that fuel and labor are not our only items of expense. The public get an inkling of the expenses of these items and conclude that the biggest part of our receipts is applicable to dividends.

Does any one, in figuring service from isolated or municipal plants, ever include interest, depreciation and taxes? Is there any better way to keep this in the public mind than by charging a certain amount for "readiness to serve?" If they have to pay for readiness to serve, they will include this item in their estimates when they start to figure what it will cost them to serve themselves.

I recommend this system to you as one that will develop your business, repress agitation for municipal ownership and the granting of competitive franchises, meet the competition of isolated plants and other means of illumination. I believe it will reduce the cost of production, better your load factor and regulation, lower the kilowatt cost to the consumer, increase the stability of your business, strengthen your securities and increase your earnings; in short, prove a panacea for most of the ills to which the average central station is heir.

High Efficiency Lamps

Their Effect on the Cost of Light to the Central Station

by

S. E. DOANE

Presented before the
National Electric Light Association
May 1910

(Reprinted from Proceedings National Electric Light Association,
Vol. I, May 1910, pp. 152–170)

INDEX

High-Efficiency Lamps

Their Effect on the Cost of Light to the Central Station

By S. E. Doane

1910

Introduction

In beginning this paper permit me to acknowledge my indebtedness to several central-stations that have freely opened their books to us and to those who have given us their time for consultation and advice, and to Messrs. Merrill, Cooper and Eisenmenger of my staff for working up the material.

It is the purpose of this paper to discuss briefly the effect of the high-efficiency lamp upon the cost of light to the central station as developed by our experience, observation and analysis.

It became obvious to the lamp manufacturer when the new high-efficiency lamps came upon the market that there were many problems connected with their use concerning which we should have information. These lamps were so much more efficient than any with which we had had experience that there was no basis from which it was possible to determine just what course to follow in placing the new lamps before the lighting industry and the public.

Under such circumstances our only recourse was to determine the best policy to follow from a careful analysis and study of the conditions under which the lamps were to be employed.

The author of this paper consulted central-station men of much experience from all parts of the country who operate all types of stations. A number of the men of the author's staff have been employed for a period of over two years collecting and working up statistics and data from all available sources.

It is most surprising to find that although a great many papers have been written in the last twenty years on this subject and derived questions, practically the only statistical information which is available for independent discussion is to be found in the reports of the United States census and in the reports of the various state commissions.

These figures are not given in such detail that they can be understood without further detailed knowledge of the business itself, consequently it is through the assistance of the central stations, who have freely opened their books to us and to others expert in the industry, that we are able to make such detailed analysis as we take pleasure in presenting to you today.

Historical Development of Cost Analysis

Among all the papers, articles, discussions, etc., the contributions of two men who have been recognized as pioneers in the discussion of certain fundamental features of the subject stand out by themselves. Practically all of the contributions other than those of these two men have dealt with details of the broad plan of cost analysis proposed by one or the other, or both.

Few of the papers published within the last twenty years have been based upon a fundamental cost analysis, but rather upon the effect on the customer, etc.* It is not possible to give due credit to the numerous authors whose thoughts and opinions we have studied with both pleasure and profit, and I trust you will understand that it is not my purpose or desire in presenting these figures to underrate for a moment the stupendous amount of work which has already been done on this subject.

Dr. John Hopkinson, F. R. S., in the presentation of his presidential address on the "Cost of Electric Supply," delivered before the Junior Engineering Society in London in 1892, succeeded in establishing a broad principle which if it had been recognized to any extent previously, had never before been presented to the public in such an authoritative or conclusive manner that it was recognized and accepted by the industry as a whole. Dr. Hopkinson

*It is rather interesting to trace the relative amount of attention given to the rate question during a number of years by noting the number of references listed on the subject in the *Engineering Index*. From 1892 to 1897 six references were made to articles on rates appearing in American publications. About this time the Wright maximum demand system of charging awakened considerable interest, as we find that in 1898 six references were made to articles on rates, five in the succeeding year, three in 1900 and four in 1901. Then for a period of four years but two references were made each year until 1906, when interest in the question seems to have subsided still more, as but one reference was made. The advent of the high efficiency lamp and the fact that it was becoming a commercial factor may have been the cause for a revival of interest in regard to methods of charging, for in 1907 five references to the subject were made, five in 1908, and four in 1909. The reference to tariffs and rates in foreign magazines shows a similar awakening of interest abroad within the last four or five years, the number of references on the subject from 1892 to and including 1906 being but eleven, while the next three years showed a total of sixteen. Altogether seventy-four references are made, showing that considerable attention has been given to the subject of proper rates, tariffs or charges for the central-station service.

divided cost into fixed and operating classifications, which division is universally recognized and conceded today to be correct.

Mr. Doherty, in 1900, in a paper before this Association, presented the same idea, having worked it up independently, but Mr. Doherty proceeded to further divide the fixed costs, showing that it was not proper to apportion them entirely by the customer's maximum demand.

Inasmuch as Mr. Doherty absolutely and completely recognizes Dr. Hopkinson's division of costs into fixed costs and operating costs, but goes further, in that he separates the fixed cost into two subdivisions, it is obvious that if we attempt our cost analysis on the basis suggested by Mr. Doherty, it is entirely possible for us to view it from the standpoint suggested by Dr. Hopkinson by combining the two divisions of the fixed cost, whereas the contrary is not true; consequently throughout this paper we have proceeded along the lines indicated by Mr. Doherty with the expectation that the paper will be of equal value from either the Hopkinson or the Doherty standpoint.

Premises Adopted for This Analysis

In discussing the effect of the high-efficiency lamp on central-station costs, let us first agree upon the premises on which we base our analysis and argument.

First. Let us agree that our discussion is limited to the lighting load.

Second. Let us agree that in order to obtain a fair average and to include the yearly mid-winter peak our analaysis must cover a period of at least one year.

Third. Let us agree that the average equipment in the country as a whole must be considered to be not excessive for the maximum demand from the standpoint of a cost analysis.

Fourth. Let us agree that all items of out-go, including dividends, interest, depreciation, obsolescence, and all losses, are as much items of cost as the usual items of coal, labor, etc.

Cost Analysis of a Number of Central Stations

As a basis for the discussion which is to follow, I wish to present the results of a careful cost analysis of a number of central stations, which is summarized in Table I. In this table four separate cases,

TABLE I

Central-Station Cost Analysis

Item		Per Cent of Total Station Expense	Per Cent Item Proportional to Output	Per Cent Item Proportional to Demand	Per Cent Item Proportional to Consumers
	a	12.7	....	75.4	24.6
General	*b*	14.5	....	71.0	29.0
Expense	*c*	10.2	....	82.8	17.2
	d	10.9	....	80.0	20.0
	Weighted average	12.0	....	76.9	23.1
	a	15.2	50.2	26.4	23.4
Distributing	*b*	9.7	44.7	21.4	33.9
Expense	*c*	17.8	50.6	24.7	24.7
	d	12.8	31.8	56.9	11.3
	Weighted average	14.4	47.0	28.9	24.1
	a	13.4	80.7	19.3	....
Generating	*b*	17.7	74.6	25.4	....
Expense	*c*	32.1	70.3	29.7	....
	d	32.3	67.9	32.1	....
	Weighted average	23.9	72.0	28.0	....
	a	8.1	....	80.0	20.0
Taxes and	*b*	10.9	....	86.2	13.8
Insurance	*c*	6.8	....	85.9	14.1
	d	4.4	....	80.0	20.0
	Weighted average	7.8	....	84.0	16.0
	a	11.6	....	80.0	20.0
	b	11.5	....	79.5	20.5
Depreciation	*c*	9.0	....	85.9	14.1
	d	6.0	....	80.0	20.0
	Weighted average	9.8	....	81.8	18.2
	a	39.0	13.1	68.1	18.8
Interest and	*b*	35.7	27.2	55.1	17.7
Dividends	*c*	24.1	26.4	61.4	12.2
	d	33.6	8.9	73.7	17.4
	Weighted average	32.1	19.7	63.7	16.6
	a	100.0	23.5	58.5	18.0
	b	100.0	27.2	55.1	17.7
Total	*c*	100.0	37.9	50.8	11.3
	d	100.0	28.9	59.5	11.5
	Weighted average	100.0	30.3	55.1	14.6

"*a*" Represents a large central station giving free renewals.
"*b*" Represents a large central station giving free renewals.
"*c*" Represents the average of about 70 stations in the East.
"*d*" Represents the average of about 40 stations in the West.

designated as "*a*," "*b*," "*c*" and "*d*," are shown, together with their weighted average.

In the foregoing table, "*a*" represents a large central station giving free renewals, "*b*" represents another large central station operating under considerably different conditions, but also giving free renewals, "*c*" and "*d*" represent the average conditions of a number of small central stations. There are about 70 central stations in the East represented in "*c*," and about 40 in the West in "*d*."

We have analyzed the figures of central stations of lesser size than the two large ones indicated by items "*a*" and "*b*," and of greater size than those indicated by items "*c*" and "*d*." The figures are not of interest excepting to confirm the findings in the table.

Method of Analysis

The percentage distribution of the total cost under the items "General Expense," "Distributing Expense," "Generating Expense," etc., is shown separately for each of the four cases represented in the column headed "Per Cent of Total Station Expense." Each of these items has been further analyzed and distributed by percentage under one or more of the headings as shown in the last three columns of Table I. The portion of each item charged to "Output" represents the relative proportion of the cost which depends upon the number of kilowatt hours generated. The portion charged to "Demand" represents the relative proportion of the cost which depends upon the capacity of the station, which in turn depends upon the "Demand." The portion charged to "Consumers" represents the relative proportion of the cost which depends upon the number of consumers connected and served. The analyses were actually carried out in considerably greater detail as to the items of expense considered, but have been grouped under a few general heads in Table I in order to present the results in a simple form.

In preparing the foregoing table, each item of cost has been carefully considered and has been listed under fixed cost or operating cost, or has been divided and part listed under one head and part under the other. The fixed costs have been divided into two subdivisions, one of which we call the "Demand Cost," the other the "Consumer's Cost." After a proper allowance for the diversity factor, this demand cost, expressed as a fixed charge per kilowatt of maximum demand, indicates, in our judgment, the amount which

would properly cover the cost involved in supplying the maximum demand. This cost is one of the two components which go to make up the total fixed cost. It may be claimed that this demand cost is not the same per kilowatt of maximum demand for all sizes and classes of customers. The advocates of this view tend to increase the demand cost per kilowatt of demand to the small customer, consequently any concession to this view magnifies this feature of the cost analysis for customers of the average size and smaller customers.

The customer's component of the fixed cost, for the average customer, is a cost which an individual customer causes, whether or not he actually consumes any current. It will be claimed that this customer's cost is also not fixed. The tendency in supporting such a claim is to decrease somewhat such cost for a small customer.

It is not possible, within the confines of one paper, to discuss these features in detail; in fact a more extended investigation and more data are necessary.

We applied the following rules to determine these cost divisions:

If an analysis of any item showed that an increase of 100 per cent in the number of customers, without the total output or total demand necessarily being increased, would presumably double the expense, such we will say as in the reading of meters, we would class that item as an expense which varied directly with the number of customers, that is, it would be 100 per cent consumers' expense.

If a particular item of cost would be doubled with an increase of 100 per cent in the capacity of the plant, even though the number of customers remained the same, we would put that item in the class which varied directly with the demand.

In a similar way, items would be classified under output.

Discussion of Analysis

An analytical separation of these costs develops curious conditions. For illustration, the coal consumed in the station does not vary directly with the output. It depends in part upon the maximum demand. It takes more coal to supply a given number of kilowatt-hours with a high demand or peak than with a low one. This shows that we must put a portion of the cost of coal under the demand cost and a portion under the output cost.

There are many other fixed and operating costs which do not fall entirely under any single one of these three general divisions of cost. As a further example, an actual destruction of transformers or apparatus in service could not be said to vary with demand, but is rather a profit and loss matter. Losses through floods or other losses of such general character, even though they be costs of repair of generating apparatus which it would seem might belong to demand cost, might really have to be distributed as a loss and hence be considered as a negative profit and be applied to all three divisions of cost.

There is another phase of the matter. Invested capital may be so applied in anticipation of future needs that the cost of an item for double the service now being rendered need not necessarily be double the present cost. A building which at present is not being utilized to its full extent would arbitrarily place a higher charge against a certain division of cost than at first thought would seem to be justified. It might be shown, however, that had the building been built the exact size when the plant was first constructed further construction would have been so expensive that when the proposed capacity of the larger building would have been reached in this manner the larger building was much the cheaper, counting all the interest, additional charges, taxes, etc.

There are many vexing questions of this character and there is much opportunity for extended consideration of this broad question of cost when once the basic principles shall have been firmly established by usage. These questions of detail, however, are not usually of sufficient magnitude to affect our broad deductions appreciably.

Many of these questions arise when one begins to consider the classifications of the fixed costs or charges. These classifications require the inclusion of some charges along with those which are really fixed, which are not generally considered as fixed charges. There are many general office charges and some station costs, such as in the class of the supervisory and technical salaries, etc., etc., which are fixed from the standpoint of a going concern, but which might disappear or be reduced in case such a concern was purchased by another.

Consumer Costs

As we go further into this subject, the extreme importance of the consumer's cost, especially in the case of the small consumer, must

be conceded, and, consequently, we have distributed these costs with extreme care.

We believe that the percentages we give in the table are conservative and that they indicate, at least, the nominal cost at which a new customer can be added to the system on the present basis.

We must concede that every customer, no matter how small, must have a pair of wires and necessary poles, fixtures, conduits, etc., to bring the wires to his premises. We must concede that he must have a meter or some current-limiting device and that he must demand some attention in the way of meter reading, inspection, billing, etc., etc. Consequently, we must all agree that any given customer, as pointed out by Mr. Doherty, costs the central station some definite minimum amount per year or average month, even though it may be that he uses no current whatever.

The three divisions of costs, indicated above, are commonly referred to as the "Demand Cost," the "Consumer's Cost" and the "Output Cost," and in analyzing costs of rendering service and energy to individual consumers are conveniently expressed as unit costs in terms of kilowatt of maximum demand (or equivalent unit, such as floor space illuminated or light delivered), the customer, and the kilowatt-hour, respectively.

It is a matter of much interest to discover that, although individual cases differ from each other, the differences are largely cancelled in the final summary. The station which has a large distribution net-work, and a few customers, will probably have a relatively large cost per consumer. The plant which operates with water power or whose investment is large for physical reasons would have a large demand cost. Either or both of these cases may be warranted by a very low kw-hour cost due to the use of cheap coal or water power, etc.

Demands

The two large central stations mentioned in items "*a*" and "*b*" of the table have rather large average customers. Their average customers consume about 3.6 and 2.3 kilowatts, respectively, at the time of maximum demand.

The Massachusetts Commission report would indicate that the average customer of Massachusetts consumes about 1.5 kilowatts

at the time of maximum demand. The Wisconsin Commission report would indicate 1.8 kilowatts as the average maximum demand.

The average customer referred to in Mr. Lloyd's paper read before this Association a year ago shows that the lighting customers he considered consumed about 0.7 kilowatts at the time of maximum demand. We understand, of course, that Mr. Lloyd does not mean that this is the average size of the Chicago consumer, but is only the average of the particular classes which he discussed.

Load Factors

Mr. Lloyd's discussion before this Association meeting last year also showed the load-factor to vary from 5 to 26 per cent. Our observations would tend to confirm these figures and our further analysis indicates that 11 per cent is about the right load-factor to apply to the average consumer. We have also assumed that a load-factor of 7 per cent may represent a short-hour user and a load-factor of 20 per cent a long-hour consumer.

The term "load-factor" in this connection is used to mean the percentage which the actual kilowatt-hours consumed in a year bears to the total number of hours in a year, namely, 8760 times the maximum demand.

So much for the facts.

Effect of High-Efficiency Lamps on Average Customer

Let us now discuss the effect of the high-efficiency lamps on the cost of serving the central station average customer, after which we will consider the effect of the high-efficiency lamps in serving larger and smaller customers with larger and smaller load-factors.

With the figures in the foregoing portion of this paper as a basis, we have plotted some diagrams which show the effect of the adoption of the high-efficiency lamps by a customer of 1.6 kilowatts maximum demand and 11 per cent load-factor. (See Fig. 1.)

I want to interpolate that the average customer may or may not take 1.6 kilowatts maximum demand and have an 11 per cent load-factor, but whether this is the maximum demand and load-factor or not, the figures in the diagram on page 90 apply to the average customer, because these figures are based on the percentages we obtained from an analysis of the total cost of the plant.

We have chosen to represent graphically the relative distribution of the three items of cost entering into the cost of serving the

individual consumer under various conditions by rectangles divided into three parts, which show, according to the relative size of the parts, the magnitude of the several items of cost.

The fixed customer's cost is indicated by the letter "*c*." The total demand cost for 1.6 kilowatts maximum is indicated by the letter "*d*" and the total cost of the kilowatt-hours actually consumed is represented by the letter "*o*." In this chosen representation "*c*" is for 14.6 per cent of the total, "*d*" is 55.1 per cent, and "*o*" is 30.3 per cent of the total. This, you will note, represents the average figures obtained from the foregoing tabulated analysis.

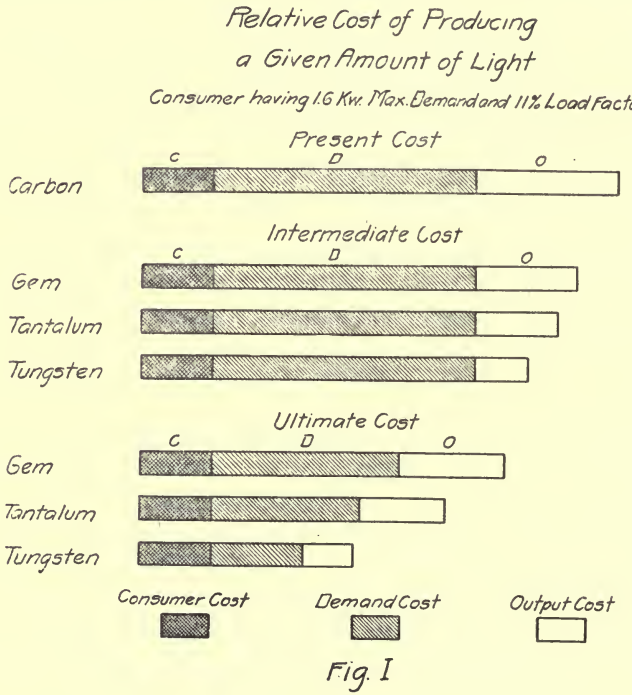


Fig. I

The first single rectangle in Fig. 1 represents the cost of the *average consumer*, which we have assumed to have 1.6 kilowatts maximum demand and a load-factor of 11 per cent. Let us assume now for a moment that this average customer changed to some one of three high-efficiency lamps, and obtained the same amount of light as before. The result is shown in the middle group of diagrams in which the longest parallelogram shows the effect on the cost of the adoption of the Gem lamp, the next the tantalum lamp,

and the third the high-class tungsten filament lamp. You will note that without adding any new customers, the central station is unable to reduce the demand cost, which is charged against the customer, and that the sole reduction in cost is therefore due to the reduction in the number of kilowatt-hours required to produce the same amount of light in a more efficient manner.

In the illustration before you the immediate reduction of cost due to the adoption of the Gem lamp is 8.7 per cent, the reduction due to the adoption of the tantalum lamps is 13 per cent, and the reduction due to the adoption of the high-class tungsten filament lamp is 19.5 per cent. It is evident, therefore, that even though the consumer's consumption of energy is reduced two-thirds, the cost of light is only reduced by two-thirds of that portion of the cost which varies with the kilowatt-hours. The total cost reduction is, therefore, only about 20 per cent instead of 60 per cent.

In all these assumptions the renewal cost of the lamp has not been considered to have increased, since it is believed that the general practice of central stations everywhere is to charge the difference between the cost of the carbon lamp and high-efficiency lamps to the customers, and as this cost of light is being considered from the standpoint of the central station the cost of renewal does not figure therein.

In the same diagram the lowest group composed of the three short rectangles shows what happens when the station has added enough customers to utilize entirely its output after every customer has been changed to high-efficiency lamps. This shows that by the adoption of the high-class tungsten filament lamp the cost of producing light for the average consumer is reduced 55 per cent.

A tabular expression of these diagrams is given later in a complete summary.

Effect of High-Efficiency Lamps on Small Customer

The total cost to the station for the individual customer can be determined when the maximum demand and the load-factor are known. Assuming a customer of small size, having, we will say, 0.5 kilowatts as maximum demand, let us analyze the cost conditions with both short and long hour use as represented by load-factors of 7 per cent and 20 per cent respectively. The results are indicated in Figures 2 and 3.

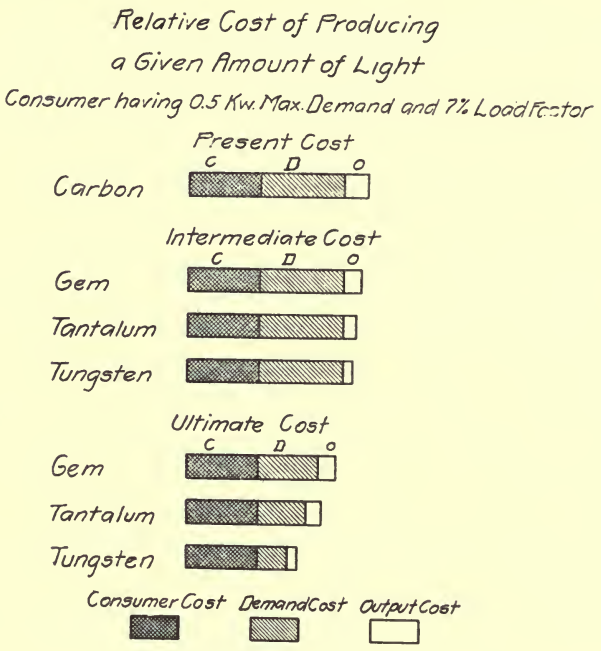


Fig. 2

I will say that, if our assumption of 1.6 kilowatts as the average demand of a customer is wrong, this quantity 0.5 kilowatts is also wrong numerically, but still illustrates correctly the effect on the cost of serving a customer of one-third the average size, whatever that average size may be.

We find that when such a customer is a short-hour user, the cost of kilowatt-hours is only about 16 per cent of the total cost, when the customer uses carbon lamps, and is only about 6 per cent of the total cost when the customer uses the highest efficiency lamp, and we further develop the astonishing fact that even when such a customer receives the maximum benefit of this new lamp by addition of enough customers to employ the entire capacity of the central station, when utilized with high-efficiency lamps, the cost of actual energy consumed is still only about 10 per cent of the total cost of carrying such a customer. Further reference to the comparative values shows that even in the case of a long-hour user having the same maximum demand the kilowatt-hours consumed cost the central station but a very small part of the total cost for the customer. Most of the cost in the case of the small consumer is involved in supplying service of one character or another. These

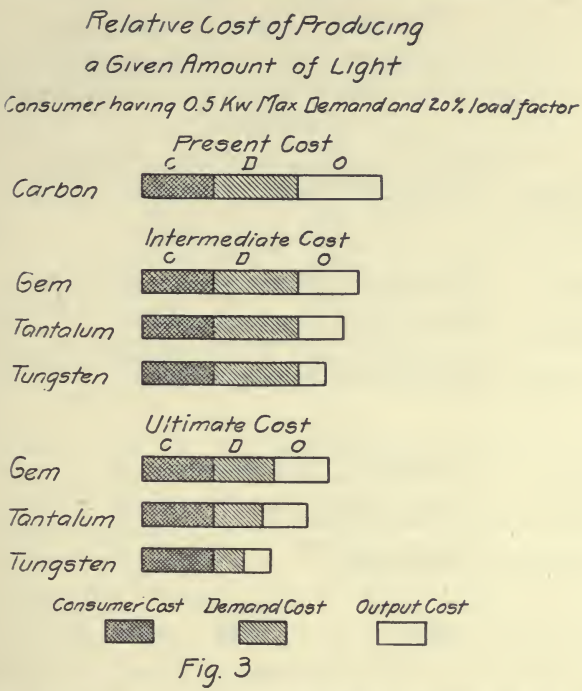


Fig. 3

diagrams indicate that the high-efficiency lamp reduces the cost materially of producing a given amount of light for such a customer, but that in the case of the average small customer the reduction in cost is in no sense comparable with the reduction in energy required for a given quantity of light.

Reference to the diagram shows further that the cost of supplying current is a small percentage of the total cost, and a reduction of a small percentage in that cost gives almost no saving in cost whatever. If we succeed in fully loading up the station with lamps of higher efficiencies, the cost of the smaller customers will be reduced to 82, 73 and 60 per cent of the present cost with Gem, tantalum and tungsten filament lamps, respectively.

Effect of High-Efficiency Lamps on Large Customer

Figures 4 and 5, representing a large consumer, show a very different situation, as it will be observed that the consumer's cost is an insignificant proportion of the whole. The first reduction in cost due to the use of high-efficiency lamps by a short-hour customer, of this size, is only about 15 per cent when such a customer uses the highest efficiency lamp most advantageously.

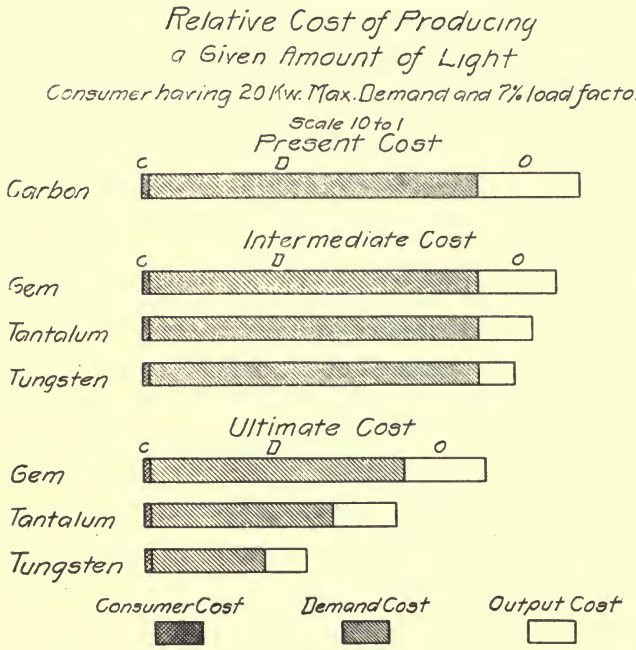

Relative Cost of Producing
a Given Amount of Light
Consumer having 20 Kw. Max. Demand and 7% load factor
Scale 10 to 1
Present Cost
C
O
Carbon
Intermediate Cost
Gem
Tantalum
Tungsten
Ultimate Cost
Gem
Tantalum
Tungsten
Consumer Cost
Demand Cost
Output Cost

Fig. 4

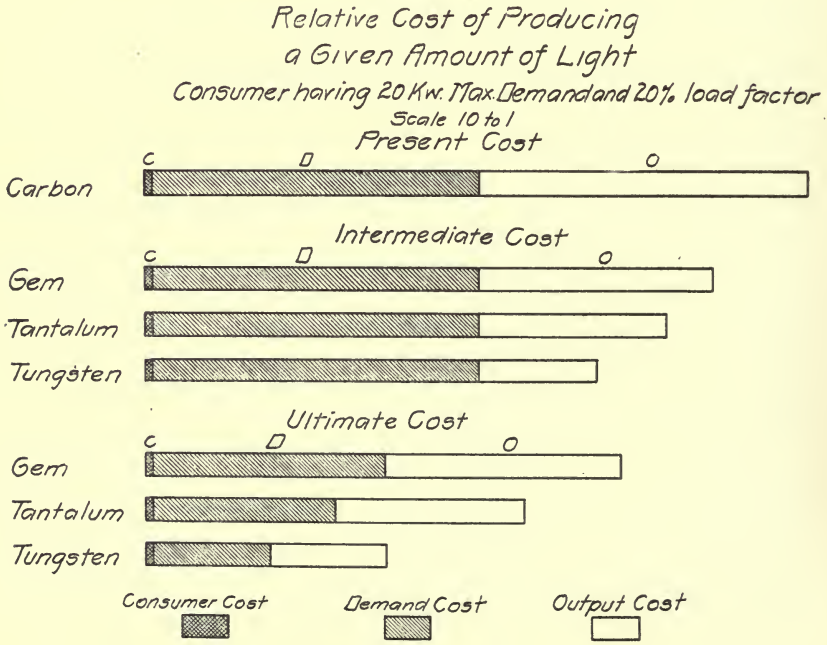

Relative Cost of Producing
a Given Amount of Light
Consumer having 20 Kw. Max. Demand and 20% load factor
Scale 10 to 1
Present Cost
C
O
Carbon
Intermediate Cost
Gem
Tantalum
Tungsten
Ultimate Cost
Gem
Tantalum
Tungsten
Consumer Cost
Demand Cost
Output Cost

Fig. 5

Summary of Above Data

A total summary of the foregoing diagrams follows:

TABLE II

Relative Cost of Serving Various Customers

Consumer	Present Cost Carbon Per Cent	Intermediate Cost Gem Per Cent	Intermediate Cost Tantalum Per Cent	Intermediate Cost Tungsten Per Cent	Ultimate Cost Gem Per Cent	Ultimate Cost Tantalum Per Cent	Ultimate Cost Tungsten Per Cent
Average	100	91.3	87.0	80.5	75.6	63.8	45.1
Small—Short-hour	100	95.5	93.2	89.8	82.5	73.8	60.6
Small—Long-hour	100	88.1	85.0	77.4	80.0	70.0	54.9
Large—Short-hour	100	92.7	89.1	83.6	71.8	57.8	36.7
Large—Long-hour	100	85.9	78.8	68.2	71.7	57.5	36.3

Consumer	Kw Maximum Demand	Load Factor
Average	1.6	11 per cent
Small—Short-hour	0.5	7 " "
Small—Long-hour	0.5	20 " "
Large—Short-hour	20.0	7 " "
Large—Long-hour	20.0	20 " "

Each consumer is assumed to use the same total amount of light after changing to the high-efficiency lamps as was used with the carbon lamps.

Effect of Adoption of High-Efficiency Lamps

The logical effect of the high-efficiency lamp is to increase the number of small consumers. This means an increase in the proportion of the central-station expense for labor in connection with the distributing system and the accounting, etc., which we have classified under "Consumer's Cost." The addition of many new customers will improve the load-factor of the station somewhat, as there is no reason to assume that the day load, which is not a lamp load, will not increase with an increase in the number of customers, even though the current consumed at the time of maximum demand does not increase because of the high-efficiency lamps.

It is of course obvious that a central station could always take care of an increased number of customers, without using high-efficiency lamps, by increasing the size of the plant, but it is also obvious that the use of the high-efficiency lamps will allow it to greatly increase the number of customers served without materially increasing the station and generating investments.

Table III, which follows, shows, on the basis of the foregoing statistics, what, in a general way, might be expected, when that time in the future arrives, when all of the central-station customers have changed to the highest efficiency lamps. Of course, we know that the time will never come when every lamp on the circuit will be of the highest efficiency. We, however, can assume any value we may desire and for the exception still use the table which follows.

TABLE III

Effect on Station Cost and Output Produced by Adoption of the Highest Efficiency Lamps

(Assuming that each Consumer produces the same amount of light with highest efficiency lamps as with the lamps of low efficiency)

Number of Consumers in Per Cent of the Number Supplied at Present with Low Efficiency Lamps Per Cent	Cost to Station				Kw-hrs. Consumed and Maximum Demand in Per Cent of that with Low Efficiency Lamps Per Cent	Relative Cost	
	Consumer Per Cent	Demand Per Cent	Output Per Cent	Total Per Cent		*Per Kw-hr. Per Cent	Per Consumer Per Cent
100 using low efficiency lamps	14.6	55.1	30.3	100.0	100.0	100.0	100.0
Changed to the following per cent using higher efficiency lamps							
100	14.6	55.1	10.8	80.5	35.7	225.0	80.5
110	16.1	55.1	11.9	83.1	39.3	212.0	75.5
120	17.5	55.1	13.0	85.6	42.9	200.0	71.4
130	19.0	55.1	14.1	88.2	46.4	190.0	67.8
140	20.4	55.1	15.1	90.6	50.0	181.0	64.7
150	21.9	55.1	16.2	93.2	53.6	174.0	62.1
160	23.4	55.1	17.3	95.8	57.2	168.0	59.8
170	24.8	55.1	18.4	98.3	60.7	162.0	57.8
180	26.3	55.1	19.5	100.9	64.3	157.0	56.1
190	27.7	55.1	20.6	103.4	67.9	152.0	54.4
200	29.2	55.1	21.6	105.9	71.4	148.0	52.9
210	30.7	55.1	22.7	108.5	75.0	145.0	51.7
220	32.1	55.1	23.8	111.0	78.6	141.0	50.4
230	33.6	55.1	24.9	113.6	82.2	138.0	49.6
240	35.0	55.1	26.0	116.1	85.7	135.0	48.4
250	36.5	55.1	27.1	118.7	89.3	133.0	47.5
260	38.0	55.1	28.1	121.2	92.9	130.0	46.6
270	39.4	55.1	29.2	123.7	96.5	128.0	45.8
280	40.9	55.1	30.3	126.3	100.0	126.0	45.1

*Please do not confuse this with the output cost per kilowatt-hour which remains practically constant throughout.

The table is drawn up on the assumption that every customer in the future will have changed to the use of high-efficiency lamps. It is anticipated, of course, that between now and the time when this condition will have been reached, that each station will have increased its number of customers; consequently, we have made our assumption to include all percentages beginning with no increase in customers and ending with 180 per cent increase in customers, at which time, the station will be again entirely loaded. This table, of course, is drawn up on the further assumption that a customer will not increase the amount of light he uses at peak hours. I firmly believe this assumption is warranted in the case of the domestic user and that it is warranted in essence in all cases, as I believe that we are rapidly reverting to a condition of somewhat increased light, perhaps, but not to an increase sufficiently great to affect materially this assumption.

I would like to say just a word as to the use of this Table III. Let us assume that a station is adding new customers on the high-efficiency basis at the rate of about 9 per cent a year. Let us also assume that a period of time, say three years, elapses before all the present customers will have changed to the highest efficiency lamps. At that time the station will be supplying 130 per cent of its present number of customers, all of whom will be using lamps of the highest efficiency. Running down the left-hand column to 130 per cent, and reading across to the final figures at the right, it shows that the average customer at the end of three years will cost the central station 67.8 per cent as much as he does to-day—even though he uses high-efficiency lamps and consumes only about one-third as much current. We find by reference to the sixth column that the actual kilowatt output in such case will be only 46 per cent of what it is today.

Some one has asked me, upon reading this paper, why we did not deal with other factors in the cost of operating a central station than that of lighting, and my reply was that lighting was the only subject upon which I considered I had any right to address this Association. This 46 per cent of present output indicates only the current used for lighting. I have no idea there is any station whose load is so purely lighting that when the 30 per cent additional customers have been obtained they will not actually have a greater output than 46 per cent of that at present, due to the day load and the power load.

This table clearly shows that those costs which we have classed as the consumer's costs, which are the costs per customer for distributing the current generated, are the costs which concern the central station to a constantly increasing extent. The investment in meters and the length of line necessary to run to reach a customer, the location of meters to facilitate reading and details of this character will be of considerably greater importance to the station man than the efficiency of the generating apparatus.

It has been suggested to the writer that the customer's cost can be reduced 50 per cent when several ends have been accomplished, among which is the universal adoption of a cheap meter, a current-limiting device or something equivalent to either, or both, etc., etc. This is a matter of speculation, but it is interesting to observe from the table that such a 50 per cent decrease would allow the central station to carry 180 per cent more customers with the same gross cost, at which time, the cost per kilowatt would be no greater than at present, and at which time, the total average cost per customer (please do not confuse this with the customer's component of the fixed costs), on the basis of our assumption, would be decreased to 36 per cent of the present total average cost per customer.

It is most interesting to note that when a station has added 80 per cent more customers that its total cost will have again reached the present cost, but that the cost per kilowatt-hour will be about 60 per cent greater than at present. It is most interesting, furthermore, in showing that even when the station again becomes fully loaded the cost per kilowatt-hour will be about 25 per cent greater than it is at present.

Conclusion

The effect of the high-efficiency lamp has been to profoundly modify commercial practice. The possibility of these lamps being made more efficient as the weeks pass makes it necessary for the central station to adopt policies, programmes and methods which not only will take care of the present high-efficiency lamp situation, but which will provide for any increase in efficiencies in the weeks, months and years to come.

Ductile tungsten wire has been produced, and it is a most reasonable expectation that the high-class tungsten filament lamps ultimately will be hardy and capable of satisfactory employment in houses or elsewhere where the supposed fragility has been argued

against them. Every customer on a central-station circuit will ultimately purchase and use lamps of this character. The situation contains a menace and a promise, a menace which cannot be ignored, a promise which must be fulfilled.

The menace is in the fact that the reduction in the cost of providing light to the average customer can never be so great as the customer expects.

He inevitably associates that two-thirds reduction in current consumed with a two-thirds reduction in cost.

The decrease in cost of furnishing light with the high-efficiency lamp is almost entirely measured by the ability of the central station to take on additional consumers who can assist in bearing the fixed expenses.

The promise lies in the opportunity.

Never in the history of our industry has there been the opportunity which now presents itself to the central station for increasing the number of its customers, decreasing the cost to each of them, and increasing profit to itself, through the use of the high-efficiency lamps.

Demand and Diversity Factors and Their Influence on Rates

by

J. R. CRAVATH

(Reprinted from The Electrical World
Vol. LVI, Sept. 8, 1910, pp. 567-570)

INDEX

Demand and Diversity Factors and Their Influence on Rates

By J. R. Cravath

1910

Introduction—Definitions

Demand factor is defined as the highest percentage of connected load which is ordinarily in circuit. Thus, if a central-station consumer has 10 kw in lamps connected and his highest maximum demand is 5 kw, he would be rated as having a demand factor of 50 per cent.

Diversity factor is commonly defined as the ratio of the sum of the maximum demands of a given group of consumers at different times to the actual maximum demand made by the group at one time. This likewise frequently can best be expressed in per cent. For example, a group of 10 consumers connected on a certain secondary main might cause a maximum demand of 3 kw on the transformer supplying that main; but if a maximum-demand meter were installed on each consumer's service the sum of the maximum demands recorded by these meters for any month might be 9 kw in certain classes of work. Expressed in per cent, the diversity factor of this load in relation to the transformer would be 33.33. This difference between the sum of the individual maximum demands of each consumer and the actual maximum demand on the transformer is, of course, caused by the fact that the maximum demands of the various consumers do not occur at the same time. In other words, there is diversity in time of maximum demand.

Importance of Demand Factor and Diversity Factor

The existence of diversity and demand factors in central-station business has been recognized since the earliest days, although it is only recently that these brief terms have come into use to express these relations. It may also be said that although the central-station industry has been dependent for its very existence on diversity and demand factors, the study of these factors has not been as thorough as it should have been. It is only recently that much activity has been shown in the study of these factors, which have an

all-important influence on the rates that central-station companies can afford to make, and hence are at the very foundation of the industry. The reason of their importance is that so large a percentage of the cost of supplying electric service is frequently made up of certain fixed charges, such as interest, depreciation and taxes, which are brought about by the necessity of providing a certain investment to take care of a certain connected load. It is evident that the larger the amount of apparatus required to supply 1 kw of connected load the greater must be the fixed charges per kilowatt connected.

Standing Costs and Running Costs

The percentage of the cost of serving a consumer which is due to fixed charges and the percentage due to variable operating expenses differ according to the class of consumer. The fixed charges are seldom less than 10 per cent and may be as high as 100 per cent of the cost of service. The fewer the hours per year the service is used the greater the percentage cost composed of fixed charges. For example, if a certain consumer contracts for electric service and the company installs meters, lines, generating capacity, etc., to supply him, and if that consumer uses no electrical energy whatever during the year, the cost of serving him evidently is made up entirely of fixed charges on the investment required, plus a small amount for keeping books, reading the meter and maintaining the office. If, on the other hand, the consumer used his entire connected load 8760 hours in a year, his fixed charges should be divided into 8760 parts to determine the amount a kw-hour. The great majority of central-station customers, however, use the service but a limited number of hours a year.

The relative proportion of total expenses chargeable to the three heads—fixed, operating and consumers' charges—has been a matter of considerable investigation. It is not likely to be exactly the same for any two plants. It is of interest, however, to cite a few examples from various recent published investigations. A very thorough investigation of this division of expenses was made by the Wisconsin commission in the recent Madison Gas & Electric Company case, decided March 8, 1910. For the year 1908, the commission found by one method of analysis that 16.7 per cent of the total cost was caused by the expenses which are the same for each consumer, entitled "consumer expenses"; 21.6 per cent were expenses proportional to the demands of each consumer, and 61.7 per cent

were variable operating expenses proportional to the kw-hours' output. By another method of analysis 58.2 per cent of the expenses were chargeable to output, being proportional to kw-hours, and 41.8 per cent were chargeable to demand. In the case of the Ripon Light & Water Company, decided March 28, 1910, the Wisconsin commission assigned about 39 per cent to capacity charges and 61 per cent to output charges.

In a paper before the last N. E. L. A. convention Mr. S. E. Doane gave the results of central-station cost analysis from 70 small central stations in the East, 40 small central stations in the West and two very large central stations. In this analysis it appeared that of the total cost 30.3 per cent was proportional to output, 55.1 per cent proportional to demand, and 14.6 per cent proportional to the number of consumers.

In a paper before the Missouri Electric, Gas, Street Railway and Water Association, in April, 1909, Mr. C. W. Hough gave an analysis of the cost of central-station service, taking as a basis the statistics given by the last United States census report on the electrical industry. He reached the conclusion that the total cost should be divided into consumer charges, 5 per cent; capacity charge, 35 per cent, and output charge, 60 per cent. These, Mr. Hough said, represented the average results as shown by the Government reports. The proportions chargeable to the various items should, of course, be investigated for each individual company, rather than taken from general averages, when any specific case is being investigated with a view to adjusting rates. The figures given are of interest merely as showing what figures have been obtained in some cases. If it is assumed that at least 30 per cent to 40 per cent of the average cost of serving consumers, and perhaps more, is caused by the maximum demand of such consumers, the importance of determining what actual maximum demand these consumers put upon the station is evidently important.

Determination of Demand Factors and Diversity Factors

It is an easy matter to determine the ratio of total connected load to maximum demand on the central station where the company has a connected load of record. However, the determination of this ratio and the determination of the percentage of the total cost chargeable to fixed expenses is by no means sufficient to afford a basis for rates. In other words, averages are worth little when the character of service required by various consumers differs so greatly. The

attempt must be made to determine as nearly as possible the actual demand and diversity factors of different kinds of loads in order that the central-station management may know what proportion of the fixed investment charges must be carried by these different kinds. If this is not done some profitable business is likely to be lost for lack of a proper rate schedule, while other unprofitable business is obtained.

There are a number of links in the chain between the consumer's lamps and the generators at the power plant. First, the demand factor or ratio of connected load to maximum demand must be studied at each consumer's premises and then the diversity factors at different points between the consumer and the power plant.

Beginning at the consumer's end, the first step is to determine the demand factor or the ratio of the consumer's maximum demand to his connected load. This determines the size of meter and service wires necessary and the consequent investment. Next, in an alternating-current system, comes the diversity factor between the various consumers and transformers, which indicates the transformer capacity necessary to serve a given kind of connected load. Next is the diversity between different kinds of load whose maximum demands occur at different times. If the system is direct current, of course the transformers are omitted and the diversity factor must be taken from the consumers' services to the ends of the feeders supplying the various mains.

This subject has not been studied enough so that many figures cannot be given on the demand and diversity factors of various classes of service and the diversity factor between these classes. A compilation of some of the available figures, however, will be given in the hope of stimulating further interest in this important subject.

Demand Factors

The Wisconsin Railroad Commission has probably carried on one of the most comprehensive series of investigations yet made to determine this demand factor or ratio of maximum demand to connected load for various classes of consumers. This commission in the case of the Ripon Light & Water Company formulated certain rates. In formulating these rates it was necessary to assume certain figures for demand factors of various consumers. These figures as fixed by the commission were based on data from a large number of other cities, but also took into account local conditions. These figures were as shown in Table I:

TABLE I

Demand Factors Assumed as Basis of Ripon Rates by Wisconsin Commission in Per Cent

Residences, flat and rooming houses	40
Public buildings	40
Ripon College	20
Schools and churches	55
Factories	55
Hotels	60
Livery stables	60
Libraries	60
Stores	75
Offices	75
Banks	75
Saloons	75
Depots	75
Theaters	75
Club rooms	75
Electric signs	100
Hallways	100
Street lamps	100

The same commission, when fixing the rates for Madison, by decision rendered March 8, 1910, specified that in figuring rates for Madison, the following demand factors should be used, as shown in Table II:

TABLE II

Demand Factors Assumed by Wisconsin Commission for Fixing Rate at Madison in Per Cent

Residence lighting, first 10 lamps	60
Residence lighting over 10 lamps or 500 watts	33.3
Stores and offices	70
Restaurants and saloons	70
Lodge and dance halls	70
Laundries	70
Depots	70
Theaters	70
Hall lamps	70
Factories	55
Livery stables	55
Churches	55
Hotels and clubs	55
Schools	55
County and federal building	55
University of Wisconsin	30
Sign and outline lighting	100
One motor under 10 h. p	90
10 h. p. installation with more than one motor	80
Motor installations with more than 10 and less than 20 h. p	70
Motor installations 20 to 50 h. p	60
Motor installations 50 to 100 h. p	55
Motor installations 100 h. p. or over	50

The Wisconsin commission has also collected data from a number of large companies using Wright demand meters by which it is possible to know the actual maximum demand of each consumer. The demand factors obtained from these companies which use maximum-demand meters vary considerably, as will be seen by Table III, which gives the highest and lowest figures reported for various classes of business.

TABLE III

Demand Factors Compiled by Wisconsin Commission from Companies Using Wright Demand Meters

Stores	40 to 100
Offices	57 to 87
Saloons	62 to 92
Restaurants	52 to 62
Factories	53 to 56
Churches	56 to 85
Hotels	28
Clubs	28
Schools	37 to 52
Laundries	60 to 75
Livery stables	52 to 58
Lodge and dance halls	68
Depots	75 to 95
Theaters	49 to 89
Shops	55
Machine shops	37 to 54
Blacksmith shops	66
County and federal bldg.	33 to 31

The Commonwealth Edison Company of Chicago has given considerable study to this matter of demand factors, and many figures covering different classes of consumers can be found in two papers presented by representatives of that company at the National Electric Light Association conventions. One of these, entitled "Load Factors," was presented by Mr. E. W. Lloyd at the 1909 convention. Another, entitled "Significance of Statistics," was presented by Messrs. George A. McKana and B. F. McGuire at the 1910 convention. In the latter paper demand factors for the month of January, 1910, for small and medium lighting customers summarized were as shown in Table IV:

TABLE IV
Demand Factors—Chicago Lighting Customers

Offices of various kinds	72.4
Residences and barns	60
Retail stores	66.3
Wholesale stores	70.1
Billboards, monuments and department stores	85.6
Average	59.8

A similar table was given for the motor users of the company in the direct-current territory where Wright demand meters are used on each consumer's service. These showed demand factors as shown in Table V:

TABLE V
Demand Factors—Chicago Motor Customers

Public gathering places and hotels	28.7
Offices	65.1
Residences and barns	69.3
Retail stores	61.2
Wholesale houses and shops	58.2
Average	59.4

The average of 59.4 per cent for motor customers is strikingly near to the average demand factor of the small and medium size lighting customers.

In the paper by Mr. Lloyd before referred to, figures on 30,729 residence consumers in Chicago show the following percentages demand factors:

Residences 0.3 kw connected load	90
Residences 0.5 kw connected load	64
Residences 1 kw connected load	48
Residences 2 kw connected load	46

Diversity Factors

In order to make a complete study of diversity factors, it is necessary to know: first, the consumer's connected load; second, the maximum demand of the consumer at his service or meter; third, the maximum demand which he places on the transformer or direct-current feeder supplying him at the time of the maximum demand

on that transformer; fourth, the maximum demand which he causes on the feeder supplying him at the time of maximum demand on the feeder; fifth, if the system is a large one employing substations, the maximum demand placed by the consumer on the substation at the time of the substation peak load; sixth, maximum demand of the consumer at the time of the generating-station peak load. The reason for studying the maximum demand at the time of the peak load at the various points named is obviously to determine the investment which must be made in the various kinds of apparatus to serve a given consumer. For example, it is the simultaneous demands of a number of consumers which determine the size of transformer necessary to serve that group of consumers.

The most complete study of diversity factor which has been made public is contained in a paper by Mr. H. B. Gear, of the Commonwealth Edison Company of Chicago, presented before the Western Society of Engineers and the Chicago Section A. I. E. E., March 23, 1910. Mr. Gear carried his analysis as far back as the substation busbars. By combining the diversity factors given by Mr. Gear in this paper with the demand factors of residence consumers given by Mr. Lloyd in the paper already referred to, some instructive figures are obtainable, as follows:

A connected load in Chicago consisting of 100 kw in residence consumers, each of 0.3 kw connected load, will cause a maximum demand at consumer's meters of 90 kw, a maximum demand at the transformers of 30 kw; a maximum demand at the feeder panel of 16.6 kw, and a maximum demand at the time of the substation peak of 14.5 kw.

For 100 kw connected residence load, consisting of 0.5 kw consumers, demands at meters would total 64 kw; transformers 21 kw; feeders 11.6 kw, and substations 10 kw.

For a connected residence load consisting of 100 kw in consumers having 1 kw connected, each, a total connected load of 100 kw would cause demands as follows: Meters, 48 kw; transformers, 16 kw; feeders, 8.9 kw; substations, 7.7 kw.

For a group of residence consumers, each of 2-kw connected capacity, the demand would be as follows: At meters, 46 kw; transformers, 15 kw; feeders, 8.3 kw; substation capacity, 7.2 kw.

For motor load, Mr. Lloyd's paper before referred to states that the ratio of average to connected load for the entire number of motor customers was 53.5 per cent. With this figure as a basis,

and using the diversity factors for scattered motor load given by Mr. Gear, a connected load of 100 kw in motors in Chicago would make the following demands: At meters, 53.5 kw; transformers, 48.5 kw; feeders, 24.2 kw; substation capacity, 21 kw.

Taking the demand figures already quoted of 66.3 per cent for retail stores in Chicago, and assuming that these figures can be safely applied in connection with the diversity figures given by Mr. Gear for commercial lighting, the following demand for a connected load of 100 kw would obtain: Demand at meter, 66.3 kw; at transformer, 39.4 kw; at feeder panel, 33.2 kw; at substation peak, 28.8 kw.

In all of the figures so far given on Chicago conditions it will be noted that the analysis is carried back only as far as the substation. The relations between the different kinds of load and the peak load on the main generating station have not been shown. This diversity between different kinds of business is very important in its influence on the generating capacity required. The following figures were obtained from some typical local curves of the Chicago system.

A typical three-phase motor circuit daily load curve in December showed that 58 per cent of the maximum load on that feeder occurred at 5 p. m., which time is approximately the time of the peak on the whole system. If this curve is a fair average, therefore, the maximum meter demand of such a motor feeder should be multiplied by 58 per cent to get the demand caused on the system at the time of the system peak load. This would give by deduction from previous motor circuit figures a station peak of 12.2 kw for each 100 kw connected motor load.

A typical residence circuit daily load curve for December, published at the same time, showed that 75 per cent of the maximum load was on at 5 p. m. The maximum load on that feeder occurred just before 8 p. m. Applying this figure of 75 per cent to the figures already quoted on Chicago residence load diversity factor, there would be a maximum demand on the station for each 100 kw connected for various classes of residence load as follows: Small residences, 0.3 kw each, 10 kw station demand for each 100 kw connected; residences of 0.5 class, 7.5 kw station demand; residence of 1 kw class, 5.8 kw station demand; residences of 2 kw class, 5.4 kw station demand.

The commercial lighting load in Chicago at the time of maximum demand is so different in different districts of the city that no general conclusions can be drawn.

At Detroit, Mich., according to figures published at various times regarding residence lighting conditions there, it appears that for a connected load of 100 kw, consisting of a large number of residence consumers per block, the maximum demand on the transformers would be 20 kw; that on the substation supplying that district 14.3 kw; and that on the power station at the time of the system peak 7.1 kw. From the last two figures it is apparent that at the time of the peak load on the system, only 50 per cent of the residence lighting load is on. The remaining 50 per cent comes on later, subsequent to the peak on the system.

At Madison, Wis., the load curves published in connection with the commission's decision already referred to indicate that for a connected motor load of 100 kw, direct current, the maximum demand is 26 kw, of which 16 kw occurs at the time of the station maximum peak. For alternating-current residence lighting in Madison a connected load of 100 kw is estimated to cause 50-kw maximum demand at the meters, and from 15 kw to 20 kw at the transformers. Alternating-current commercial lighting at Madison for each 100 kw connected will cause 50 kw to 55 kw maximum demand at the transformers. Taking alternating-current, commercial and residence lighting together in Madison, 100 kw connected causes about 30 kw maximum demand at time of station peak.

At Spokane, Wash., analysis of the load on a residence feeder shows that for 100 kw connected load, the maximum demand on that residence feeder would be 37 kw.

At Paxton, Ill., 100 kw connected load in direct-current motors causes a maximum demand on that power circuit of 26 kw, and a maximum demand at the time of the station peak in December of 6.5 kw.

In small towns the business of a central station can be mainly classified under three general headings: Motor service, residence service and business district lighting service. Conditions vary widely as to how much these three services overlap at the time of the station peak in December. In some towns it is probable that the motor load is almost entirely off at the time of the main peak load on the system. On the other hand, residence lighting is very likely to overlap the main peak, because of the custom of keeping stores open certain nights each week in the smaller towns. So few small companies have residence and business lighting feeders sep-

arated that information on this matter is scarce. Load curves from one residence and one commercial lighting feeder of the Wabash (Ind.) Water & Light Company for Jan. 3 showed the same value of combined residence and commercial peaks at 5 p. m. and 6 p. m., but the elements making up the peak were different. At 5 p. m. the residence load was 35 per cent of the combined residence and commercial load, while at 6 p. m. the residence load was 44 per cent.

The figures which have been given on maximum demand on the power station caused by a given amount of connected residence load show why it is that some central stations have added a large number of residence consumers without increasing the peak load demand much.

Application of These Factors to Rate Making

In the application of these diversity and demand factors to the fixing of rates it is, of course, necessary to know approximately the investment which the central station must make in different parts of its system under existing local conditions. In order to show the method of working out the investment required for a given class of consumers per kw of connected load, assume a hypothetical case of a residence consumer whose connected load is 0.5 kw.

Taking this consumer's connected load as 100 per cent, assume that the following demand and diversity factors have been found to apply to the local conditions under consideration: Connected load, 100 per cent; maximum demand at meter, 60 per cent of connected load; maximum demand at transformer, 25 per cent of connected load; maximum demand on feeder, 12 per cent of connected load; maximum demand on generating station at time of station peak, 10 per cent of connected load.

As to investments, assume meters at $12 each; transformer at $10 per kw of capacity; overhead lines at $50 per kw of maximum feeder demand, and power station at $100 per kw of maximum demand. For each 0.5 kw consumer there would then be the following investment: One meter at $12; transformer capacity, $10 × 25 per cent × 0.5 kw, or $1.25; lines, $50 × 12 per cent × 0.5 kw, $3; station capacity, $100 × 10 per cent × 0.5 kw, $5; investment for each 0.5 kw consumer, $21.25; investment per kw connected of such consumers, $42.50. The foregoing figures begin at the consumer end and go back to the station. It is possible to calculate the investment beginning at the station end, but it is usually most convenient to figure from the consumer's end.

Effect of Width of Maximum Demand on Rate Making

by

LOUIS A. FERGUSON

Presented before
Association of Edison Illuminating Companies
September 1911

(Reprinted from Proceedings Association of Edison Illuminating Companies, September 1911, pp. 159–165)

INDEX

Effect of Width of Maximum Demand on Rate Making

By Louis A. Ferguson

1911

Introduction

The possibility of the large prospective consumer installing his own isolated plant does not seem to completely down, and it is, therefore, highly important that schedules for the supply of large business should be carefully prepared to meet competitive conditions which are being continually presented. These schedules should take into consideration the hour's use or load factor of the business, as most of us appreciate, otherwise the Central Station will obtain the unprofitable short-hour business and lose that most to be desired long-hour profitable business.

The wholesale rate schedule should differentiate as to quantity, load factor, power factor where practicable, and even as to the kind of supply, whether alternating or direct current or whether high or low tension, and because of the comparatively small number of such consumers and their large size, it is permissible that the schedule be somewhat more complicated than the retail schedule.

This paper will deal more particularly with the subject of the proper method of measuring the maximum demand from which the load factor of these larger or wholesale consumers is determined.

Load Factor

Until very recently there has been much confusion in regard to the term "Load Factor." Even today, after years of discussion, and with a fairly good general understanding of the authoritative definition of load factor there is still much uncertainty unless explanatory statements are added. Load factor is based on two quantities: (a) The average kilowatt hours per hour consumed or generated in a given number of consecutive hours, as, for instance, in a 10-hour day, a 24-hour day, a month or a year; and (b) the maximum demand during the corresponding period.

It is now more generally appreciated that in rate making at least the yearly load factor is the only proper one to consider be-

cause fixed charges on investment are usually the most important items of cost and these fixed charges continue every hour in the entire year. The yearly load factor is for this reason coming into general use and in the absence of any qualifying statement the yearly load factor would be understood.

Methods of Determining Maximum Demand

The exact meaning of maximum demand or the second quantity, (b), would not be generally understood if not specified, especially in connection with the sale of alternating current energy. As pointed out at last year's convention by Mr. R. S. Hale in his paper on "Measuring Demand," several methods are in use for determining the maximum demand. These are: First, The so-called "non-instrumental methods," which should apply to all small lighting consumers; and, second, the "instrumental methods" which should be applied to all large consumers.

Small consumers in this statement refer to those having a maximum demand not exceeding one or possibly two kilowatts and which, therefore, include 95 per cent or more of the residential consumers in a large city. Large consumers in the foregoing statement refer to those having a maximum demand in excess of 30 or 40 kilowatts. In the latter case, the actual demand is by far the most important factor in the cost of supplying such consumer and must, therefore, be determined accurately and continuously.

The principal methods are as follows: (1) The momentary swings of an indicating or graphic recording instrument; (2) the current required to produce a given heating effect, as in a Wright demand indicator; (3) the watt-hour consumption or integrated demand during a specified interval of time, as one minute, five minutes, fifteen minutes, half hour or one hour. The last mentioned method is now being used almost exclusively in the measurement of alternating current energy, but there is still a great divergence of practice as to the interval of time and also as to whether the maximum demand charge is based on the highest individual peak or on an average of several peaks, and if so, how many.

This is extremely unfortunate and often puts the Central Station Company at a disadvantage, especially when dealing with large consumers or allied industries who operate in several cities and in which cities the prevailing practice as to interval taken in deter-

mining maximum demand may be very different. The following will, therefore, be confined largely to a consideration of most desirable intervals.

Variation in Demand Intervals

The Wright demand indicator installation used by several of the large companies answers very well for direct current installations of moderate size, but is found rather expensive for very large D. C. installations and unsatisfactory for alternating current because of the large rushes of current in the starting of A. C. motors. In direct current installations, for instance, the Wright demand indicators will, under most conditions, indicate about 85 per cent of the maximum in 5 minutes and the full maximum in 30 minutes. As this indicator has found rather wide application in several cities, the interval (one-half hour with a steady load) required to show the full maximum on this instrument naturally had some influence in fixing the width of peak over which the maximum was integrated in the sale of alternating current power.

It must be borne in mind that with a steady load there is no difference between a 5-minute and a one-hour peak. If the load is intermittent, the shorter interval will give the higher maximum demand. In making a schedule of rates for large consumers it is necessary, therefore, if the rate is to be a just one for all the users in a given class, that a fixed interval for maximum demand be established; that is, either the instantaneous, the one minute, the five minute, quarter hour, half hour, or the one hour.

If the entire output of a water power plant with long transmission lines is taken by a very few consumers, each taking large blocks of power, a short interval might be preferable.

Penalty for Poor Power Factor

In such cases it is also sometimes desirable to increase the charge to the consumer if the power factor of his load falls below a reasonable figure.

In such portions of our large cities, however, as are supplied by alternating current energy the maximum load almost invariably occurs between six and nine o'clock when it is almost exclusively lighting, and as a result the power factor is high at that time in the evening. The day load or motor load in above mentioned portions of these cities which naturally has a poor power factor is usually less

than one-half the evening load. The amount of copper in the distribution system is therefore not injuriously affected by the poor load factor in the daytime, and hence the cost to the central station company is not appreciably affected. Moreover, rotary condensers may be used in such particular sub-stations where the power factor is lower than desirable, thus insuring a high power factor on the generators, transmission lines and sub-stations, and then in the worst event only the distribution system would be affected. In dealing with large number of power consumers it is difficult enough to have them understand load factor, to say nothing of such a complicated matter as an equitable charge for low power factor. For these reasons the Central Station companies operating in large cities practically always charge for the maximum demand on the basis of true energy or watt-hour consumption and will also find many advantages in using a reasonably long interval.

Relative Advantages of Short and Long Demand Intervals

In order to separate more easily the relative advantages of short and long intervals in obtaining the maximum demand, it is well to consider a simple example—the sight reading of the dial of ordinary watt-hour meter by an observer. There are immediately apparent two causes of error: (1) the time of observation of the length of interval, and, (2) the value of the reading. Suppose the operator is allowed a leeway of ten seconds on either side of the exact time. The maximum error in five minutes would be approximately 6 per cent, while in one hour it would be less than 6-10 of 1 per cent. In the second place, assume that the meter has a constant of 1, is read directly in K. W. H. and is installed on a line using about 1 K. W. H. per minute. If the observer is allowed to interpolate to one-quarter of each division then there is a maximum possible error of ¼ K. W. H. In five minutes this would introduce an error of 5 per cent, but in one hour only 4-10 of 1 per cent. The above illustration assumes a meter constant of one, and the percentage of error given should be increased correspondingly by the larger constant always necessary for a large consumer.

Another illustration of the advantage of using longer intervals is an actual case in which power was sold to a large street railway system and metered on a number of transmission lines each delivering a coincident maximum demand of about 1800 kw. Originally one division of the lowest dial of the meter multiplied by the constant of the meter best fitted for the purpose which was on the

market at that time was something like 400 kw. This meant a maximum possible error of, say, 400 kw., which would have been prohibitive except that there were several lines used in the supply and also the average of several maxima was used. But even then the results were, of course, not satisfactory.

On the meters now in use by the same company on the very large number of railway lines delivering an aggregate of over 100,000 kilowatts one division of the first dial amounts to 1-100 kw., which, multiplied by the constant which is usually 4000, gives the value of the lowest division of the dial as 40 kw. The hourly reading is 40 kw. divided by 1800 kw. (the output for one hour) or a maximum possible error of 2.2 per cent. With a half-hour interval the error is the same, but the percentage is double—40 kw. divided by 900 kw., or 4.4 per cent. Similarly the quarter-hour error would be 8.8 per cent and the five-minute error 26.6 per cent.

In the railway business cited, hourly intervals are used and this possible error is reduced by using the average of several maxima. The maximum error of each hourly reading is 2.2 per cent. Taking the average of several cases, the error, according to the law of averages, would be only one-half of this, or 1.1 per cent, and the more we can average within practical limits the more this percentage of error will be reduced. For instance, using the average of six peaks would theoretically reduce the error of 2.2 per cent to .37 of 1 per cent.

The error in reading any integrating meter used in determining the maximum demand (and this error as shown above may be very large) would be a much smaller percentage of the total energy for a long period than for a short one; in fact, the error is inversely proportional to the interval.

Where more than one instrument is required to determine a particular customer's peak load the labor involved in computing the maximum is quite an item, as the output of all the meters for the intervals on which the contract is based must be added together to obtain the coincident maximum demand. If a 5-minute interval were used, the labor in computing the maximum would be practically 12 times as great as for the one hour. The longer interval is, of course, more favorable to the consumer with the intermittent load, as it does not penalize him for the short peaks. This feature appeals to the consumer as the primary or maximum demand charge is

usually the least intelligible to him, and the shorter the interval, the harder it is for him to understand. He realizes that the total kilowatt hours used bear some direct relation to the amount of work done, but the maximum demand, particularly if it be an instantaneous or very short interval demand, is not so well understood.

Relation Between One-Hour Peak and Various Shorter Peaks

In order to determine the relation between the one hour peak and the various shorter peaks some accurate observations, most of them very recent, were made on different classes of consumers, all but one of which are in or near Chicago, and are given in Table I:

TABLE I

		Per cent of one hour maximum		
		30 min.	15 min.	5 min.
(1)	Large street railway system	101.6	104.8	110.
(2)	Electrical steam railway terminal	....	117.	....
(3)	Interurban railway	109.	119.	126.
(4)	Large hotel	107.	107.	....
(5)	Large department store	101.5	103.	110.5
(6)	Government building (large)	103.	104.5	109.
(7)	Piano factory (average size)	102.5	107.	113.
(8)	Grain elevator (average size)	109.	113.	118.
(9)	Large stone quarry	101.8	106.	112.
(10)	Small stone quarry	105.	117.	128.
(11)	12-story office building	109.	113.	133.
(12)	19-story office building	108.	108.	138.

In the two office buildings the maximum demands under each of the three different intervals include only the elevator and general power and do not include any of the lighting. An inspection of this five-minute power load curve indicates that four extraordinary peaks at 9:20, 9:40, 12:40 and 3:50 caused the large percentage of difference between the 5-minute and the 30-minute peak on the 19-story office building. Similarly one very unusual peak at 8:30 A. M. occurred on the 12-story office building.

An analysis of the data on the large department store given in Table I indicates that if the bills for a year had been rendered on a 5-minute peak the maximum demand on primary charge would have been 8.1 per cent greater than on the 30-minute peak actually

billed, but the total bills for the year would have been only 3 per cent greater on the 5-minute than on the 30-minute peak.

The difference between the 5-minute and 30-minute peak on the piano factory would have been 9 per cent in primary charge but only 3.8 per cent in the total charge. On the grain elevator the difference would have been 7.7 per cent in primary and 3.9 per cent in total charge.

Effect of Demand Interval on Rates

While none of the differences in the three cases analyzed or in most of those given in Table I are very large they show conclusively that the width of peak should always be taken into account in establishing rates for electric service. In other words, broadening the peak is equivalent to lowering the price.

The actual result on price of a given broadening of peak depends —First, on the amount of broadening, that is, from say 5 minutes to 30 minutes, and, secondly, on the steadiness or unsteadiness of load.

The percentage difference in total income between the results obtained from 5-minute and 30-minute intervals is relatively small and it is much better to take care of a small difference of this kind by a slight adjustment in making the original primary rates than to have any possibility of the most important customers feeling that the method used is not accurate enough and not fair to them in all cases. As an illustration, assume that there is 5 per cent difference in total bill between the 5-minute and the 30-minute method. The power company should not feel that it is giving away this difference by using the 30-minute readings. In making up a schedule of rates this 5 per cent should be taken into consideration by making the primary enough higher to compensate for this difference.

Some consideration of the size of the consumer and the question of diversity factor will be worth while in a study of the relative merits of long and short intervals, and as to whether to use one reading or the average of several readings. With either lighting or power, but especially with power, the more intermittent the load and the smaller the consumer, the greater will be the diversity factor.

Demand Intervals Used by Various Companies

In order to ascertain the present practice and apparent tendency in this matter, information was secured from the companies operating in the larger cities and which is given in Table II:

TABLE II

Width of Peak Used in Different Cities in Determining Maximum Demand Charge

	General Light and power	Railway power
Buffalo, New York	2 Min.	.....
*Spokane, Washington	.....	5 Min.
New York, New York	5 to 10 Min.	.....
Cleveland, Ohio	15 "	.....
Los Angeles, California	15 "	.....
Milwaukee, Wisconsin	15 "	15 Min.
*Minneapolis, Minnesota	15 "	.....
*Rochester, New York	15 "	.....
St. Louis, Missouri	15 "	30 Min.
*Boston, Massachusetts	30 "	60 "
*Brooklyn, New York	30 "	.....
*Chicago, Illinois	30 "	60 Min.
Kansas City, Missouri	30 "	60 "
Detroit, Michigan	60 "	60 "
Philadelphia, Pennsylvania	.....	60 "

The member companies in cities marked thus * use Wright demand indicators for part or all of their D. C. consumers, but not for A. C. consumers. Those marked thus ..... in one or the other column use either non-instrumental methods for determining the maximum demand; sell on a straight kilowatt hour basis; or else sell no power for railway purposes of any kind.

In some cases a company has used different intervals at different times, but those given in Table II are those reported by them to the writer as being used in their latest contracts for power or wholesale light and power.

Arguments in Favor of Thirty Minute Interval

Only two of the companies in the fifteen of the larger cities of the country given in Table II use an interval of less than 15 minutes for general light and power; 6 companies use 15 minutes; 4 use 30 minutes and 1 uses 60 minutes. The writer believes that for the sale of general light power an interval of 5 minutes or less is unwise; also that a 30-minute interval is slightly better than a 15-minute interval and summarizes his reasons as follows:

1. Short interval readings either introduce greater percentage of error in the maximum demand or added complications and difficulty in metering.

2. Short interval readings are not necessary on a large consumer, because his load is usually made up of large number of units and therefore load is more uniform, or to express it differently, the ratio of 5 minutes to ½ hour maxima is small.

3. The existence of a very high or large diversity factor between the small consumers and also between the consumers who use their power intermittently reduces the necessity for a short interval maximum for these small or medium sized consumers.

4. The use of short and frequent intervals requires much more work to figure and is no inconsiderable item when it is considered that there is usually a subtraction of readings in one form or another and multiplication by a constant.

5. The practicability of off-setting the slight apparent concession of using a longer interval of average of more than one maximum by a slightly higher primary rate of charge per kw eliminates the necessity for use of short intervals.

6. The use of a long interval, say 30 minutes, as against 5 minutes, makes only a very slight difference in income, which may easily be allowed for in rate-making, and promotes much better relations with the consumer who can never understand why he should be penalized for an occasional or accidental demand which lasts only a few moments.

Conclusion

The writer desires that in advocating the use of a maximum of moderate length with a compensated primary charge his position should not be construed as relinquishing the advantage to the supply company of the diversity factor of its various consumers, but rather the opposite, as stated in a former paper, in which he has said:

"The diversity factor is the very foundation rock of centralized energy supply. It is the birthright of the Central Station, the fundamental basis of its existence and its resultant value belongs to the Central Station Company."

Reasonable Profit

Its Definition, Collection and Distribution

by

JAMES V. OXTOBY

Presented before

Association of Edison Illuminating Companies

September, 1910

And Revised to October 31st, 1910

(Reprinted from Legal Phases of Central Station Rate Making for Electric Supply, Printed by Association of Edison Illuminating Companies, 1911)

INDEX

* * * *

INDEX TO APPENDIX

Reasonable Profit

Its Definition, Collection and Distribution

By James V. Oxtoby

1910

Introduction

It is the purpose of this paper to state the rules established by the authorities on the subject of the reasonable profit which public utilities should receive in the course of their operations. Where no rules exist, an attempt will be made to suggest what such rules ought to be.

1. The regulation of rates for public services has assumed increased importance in the past few years. Instead of an occasional regulation of some particular public service by a State Legislature or a local legislative body, regulation of all public utilities has been undertaken as a matter of general public policy. Commissions have been created with power to regulate according to rules of general application. While local legislative bodies should be bound by the same rules as commissions, it is hardly to be expected that any well defined rules have or will be developed from their conclusions.

2. The courts have quite generally upheld the right of the legislatures to delegate the rate-making power to commissions. These commissions must necessarily have broad discretionary powers, and it is to them that we must look for the declaration and application of sound principles.

3. The subject of rate regulation is of such complexity that courts and commissions have gone slowly in declaring principles, and applying them to particular facts. The proposition that rates shall be "reasonable and just" is not new. Statutory provisions to this effect are but declaratory of the common law. The commissions, in the first instance, must determine in each case what is reasonable and just to all parties, and it is important that none of the factors in the problem be overlooked. It is desirable that correct principles of rate-making be defined and observed by these bodies, and the corrective power of the courts called upon as little as possible. Ques-

tions pertaining to rates must generally come before the commissions in the first instance, and it is their function to investigate, define, and apply correct economic principles.

4. The chief elements in determining a reasonable rate for any particular public service are (a) the fair value of the property used in serving the public, (b) the reasonable value of the service to the public, (c) the proper deductions to be made for expenses, including depreciation and obsolescence, and (d) the reasonable rate of profit or return to be allowed on the value of the property used. It is the purpose of this paper particularly to discuss the question of reasonable profit, or rate of return, which should be allowed to a public service corporation, in the making of its rates. To this question are closely related the elements of value of the property used, and the value of the service rendered.

I—Definition of Reasonable Profit

5. Judge Walter C. Noyes in his book, "American Railroad Rates" (September, 1905, p. 28) says, "What the fair return is, which a railroad is entitled to receive, cannot be determined by the application of any fixed standard. It must vary with the period and with the conditions. It should be sufficient and only sufficient to lead to the continued investment of capital in railroads. Rates should be so adjusted that the total revenue produced by them will compensate the railroad, to the extent that the same amount of energy expended in other branches of productive industry is compensated."

6. Professors Beale and Wyman in their work on "Railroad Rate Regulation" (July, 1906, Sec. 312), say, in discussing the reasonableness of an entire schedule of railroad rates: "The determination of the actual amount of the capital invested may be a matter of some difficulty. Once determined, the rate of profit upon that amount of capital is a question which will be determined, generally speaking, by the ordinary business profit of the time and place. A schedule of rates will be reasonable from the point of view of the carrier, if it yields him a net profit equal to that which would be realized, as a business question, from any other business where the capital and the risk are the same."

7. In giving a talk to employes on "Rates and Costs" in March, 1907, Mr. Alex Dow gave this short and concise definition: "A reasonable profit to people who invest their money in any busi-

ness, is that amount of profit which will bring to the business freely the amount of money which it needs; neither more than that, nor less than that."

8. The Railroad Commission of Wisconsin, in its opinion in the case of the Madison Gas & Electric Company, (March 8, 1910, See appendix), says: "The rate that may be considered a reasonable return for interest and profits on the investment, undoubtedly varies with the circumstances. Generally speaking, however, it can perhaps be said that under normal conditions it consists of the ordinary rates for capital similarly invested, and that are sufficiently high to encourage investors to put their money into such enterprises."

9. The editor of the "Railway Age Gazette" (issue of July 1, 1910) in an article, "The New Epoch of Railway Affairs," stated: "It ought to be plain to every thinking business man that the profits on any one industry cannot be arbitrarily restricted, while the profits of other concerns are not limited, without inviting diaster. The public can perhaps determine what returns shall be earned on the present investment of railways; but it cannot compel future investments in them. Each investor will insist on having the profit to which he thinks he is entitled, regardless of public opinion on the subject, and the effect of providing that only a small return shall be derived form the railway or any other business, will simply be to drive the investment from that business to other businesses whose profits are not limited."

10. In this paper the conditions and circumstances will be considered which should influence, or control, the fixing of the fair rate of profit. A utility company is particularly interested in the total returns from its entire schedule of rates. It is also interested in the distribution of profit over particular rates, for this will have much to do with the growth of its business. A customer is particularly interested only in his own rate.

11. If the rate of profit is too low, money cannot be readily obtained for the development of the business. If it is too high, competition is invited. It is coming to be generally conceded that a utility, which must occupy the streets with poles, wires, conduits, pipes or tracks, is a natural monopoly, and that regulation, and not competition, is the best remedy to be applied in its control. Competition chiefly acts to reduce that part of the rate which consists of

profit. It does not have much effect upon the costs which constitute the remainder.

12. The question of reasonable profit does not ordinarily present itself, until after a utility has been built, and has been in operation for a sufficient length of time to show results. At the outset, the utility must adopt a tentative rate or schedule of rates, the results of which can only be conjectured. No court or commission has ever been called upon to pass upon the reasonableness of a rate in advance of the building of the plant. In all cases where the question of the reasonableness of rates has been so passed upon, the rates have been in effect for some time. It has in all cases been possible to value property already in existence, and to test the proposed rate by calculating the return it would have realized, if applied to past business.

13. No court has yet decided what is a reasonable rate of profit. The courts in most cases have merely reviewed the decisions of legislative or administrative bodies, which have, in the exercise of their powers, fixed certain rates. The usual occasion for review has been an attack on the validity of the rate on the constitutional ground of confiscation. Even in the few cases where the decisions of the commissions have been reviewed under statutory provisions, the courts have emphasized the strong presumption which exists in favor of the rate as fixed by the administrative body. In some States, this presumption is declared by statute.

14. The courts in their decision have, as stated, generally confined their inquiries to the question whether the rate as fixed was so confiscatory as to violate constitutional principles. They have not undertaken to themselves exercise the rate-making power, nor to consider general questions of expediency, public policy, or the best interests of both company and customer. All these have been recognized as matters which must be considered by a rate-making body. They have not, however, been considered by the courts, except as bearing directly on the question, whether the rate fixed was so unreasonable and unfair, as to deprive the company of its property without due process of law.

15. The courts have thus far approached the question as they have that of tax assessments. It is a general rule that if an assessment has been made in good faith by the assessing officer, and is not manifestly unfair, it will not be disturbed by the courts. There is such a range for the operation of individual judgment on the ques-

tion of assessable value, that it cannot ordinarily be said that a particular value is too high or too low. Tested by legal principles, any value within a given range is proper.

16. The same is true of rates for a public service. The fixing of the proper rate of return is a matter of sound judgment, and the courts have recognized the principle, that where sound judgment has apparently been exercised, and the results are not manifestly unfair, they should not be interfered with. Where, however, the results are clearly unfair, or where it is evident that the rate-making body has not investigated the question in good faith, the courts have not hesitated to interfere, and it is in this class of cases that they have been called upon to state the law.

17. This view is well put by the court in the case of Minneapolis, St. Paul and Sault Ste. Marie Railroad Company vs. Wisconsin Railroad Commission, 136 Wis. 146,—where this language is used:

> "In reviewing the order of the Railroad Commission the inquiry is not whether the rate, regulation, or service fixed by the Commission is just and reasonable, but whether *the order* of the Commission is unreasonable or unlawful. The nature of the inquiry is changed at this point, and the court is not investigating for the purpose of establishing a fixed point. Whether or not the order is within the field of reasonableness, or outside of its boundaries, is the question for the court. It is quite a different question from that which was before the Commission in this respect. The order being found by the court to be such that reasonable men might well differ with respect to its correctness, it cannot be said to be unreasonable. From this aspect it is within the domain of reason, not outside of its boundaries. This is the viewpoint of the reviewing court."

18. In this paper we are not concerned particularly with legal questions, although a number of court decisions will be found cited in the appendix. We shall try to place ourselves at the viewpoint, not of a court to which appeal may have been made from a rate already fixed, but of the rate-making body. What elements should such a body consider in arriving at a sound conclusion upon the question of the reasonable rate of profit? There must be some principles to guide in the determination of what rate a public utility should earn, and the public should pay.

19. As already stated, the rate of return must be such as will readily bring the needed money into the business. It should not be the policy of the rate-making body to first permit the investment of capital in public utilities, and when the investment has been made,

to so limit the rate of return upon it, that those who have made the investment have reason to regret doing so. Capital already invested should receive exactly the same consideration and treatment as capital about to be invested. The former should be fairly treated, and the latter should not be invited with the prospect of a profit not inherently reasonable. While the foregoing principle should be axiomatic, difficulties arise in its application to specific cases.

20. From the decision of the United States Supreme Court in the Consolidated Gas Company case (see appendix), some have gained the impression that it has been decided that six per cent is a fair rate of return. This case is, however, merely one of the class already (14) referred to. It merely decided that six per cent was not unreasonably low. The New York Legislature has passed two acts, one limiting the price of gas sold to the city of New York to a sum not to exceed 75 cents per M. cubic feet, and another limiting the price in the boroughs of Manhattan and the Bronx, to consumers other than the city of New York, to 80 cents per M. cubic feet. The New York Gas Commission (succeeded by the Public Service Commissions in 1907) had also made an order providing that the price of gas in the city of New York should not be more than 80 cents to consumers other than the city of New York.

21. Both the legislature and the commission had exercised their judgment in the matter, and their decision was not to be overruled, unless it resulted in manifest injustice. The court in its opinion stated: "The rule by which to determine the question (as to the validity of the acts of the legislature and commission) is prétty well established in this court. The rates must be plainly unreasonable to the extent that their enforcement would be equivalent to the taking of property for public use, without such compensation as, under the circumstances, is just both to the owner and the public. There must be a fair return upon the reasonable value of the property at the time it is being used for the public." The court concurred in the opinion of the trial judge that "a rate which would permit a return of six per cent would be enough to avoid the charge of confiscation." In concluding, the court said, "Upon a careful consideration of the case before us, we are of the opinion that the complainant (the Gas Company) has failed to sustain the burden cast upon it, of showing beyond any just or fair doubt that the acts of the legislature of the State of New York are in fact confiscatory." The bill of complaint was dismissed, without prejudice to

the company's right to again have recourse to the court, if actual experience under the rates prescribed prevented it from earning a fair return.

22. The trial court had found that the company was operating "the most favorably situated gas business in America." In discussing the question of reasonable profit, Justice Peckham said, "There is no particular rate of compensation which must in all cases, and in all parts of the country, be regarded as sufficient for capital invested in business enterprises. Such compensation must depend greatly upon circumstances and locality. Among other things, the amount of risk in the business is a most important factor, as well as the locality where the business is conducted; and the rate expected and usually realized upon investments of a somewhat similar nature with regard to the risk attending them."

23. In the Knoxville Water Company case (see appendix), the United States Supreme Court held that interference by the Court was not warranted, it appearing that the value of the Company's property was open to such question, that the effect of the rate fixed by the city ordinance was speculative. The Company's bill of complaint was dismissed without prejudice, with the right to again apply to the court for relief, if thereafter it should appear, under the actual operation of the ordinance, that the returns allowed by it operated as a confiscation of property. It was clear, upon any view of the evidence, that the company would receive some compensation under the ordinance rate; the question of how much was entirely speculative. As stated by Justice Moody, "The net income in any event would be substantially six per cent, or four per cent after an allowance of two per cent for depreciation, etc. We cannot know clearly that the revenue would not much exceed that figure."

24. The Railroad Commission of Wisconsin has in several cases exercised the authority given to it to fix just and reasonable rates and schedules for electric, gas and water utilities. In the case of Menominee and Marinette Light and Traction Company (decided August 3, 1909, see appendix), the Commission used a rate of 7% on the cost of reproduction new as the basis for the schedule of rates ordered to be put into effect. In the case of Antigo Water Company (decided August 3, 1909, see appendix), the Company's net earnings did not much exceed six per cent, and the Commission declined therefore to order a reduction in the water rates.

25. In the case of Madison Gas & Electric Company (decided March 8, 1910, see appendix), the Commission used 7½% as the reasonable return upon the value of the gas plant, and 8% as the reasonable return upon the value of the electric plant. The Commission allowed 6% in each case *for interest*, with an additional 1½% and 2% respectively *for profit*. The plants were considered as favorably situated, their credit good and their earnings safe. The utility was held entitled to something more than mere interest on its investment. The gas plant had in the past earned 7½% on the value of the investment, and the electric plant had in the past earned 8%, thus indicating in the opinion of the Commission that the cost of reproduction represented the maximum value for rate-making purposes, and that no additional value should be credited to represent the cost of building up the business.

26. In arriving at the present value of the plants, the Commission considered the cost of reproduction new, the cost of reproduction new less depreciation, their original cost, book value, and capitalization, their gross earnings, operating expenses and net earnings, and the cost of building up the business as shown by the value of the gas plant when computed on a 7½% earning basis, by the value of the electric plant when computed on an 8% earning basis, and by the value of both plants combined when figured on an 8% earning basis. The risks of the electric business were considered greater than those of the gas business, and a larger return for interest and profit was therefore allowed upon the present value of the electric plant.

27. In the Coney Island Fare cases (decided March 8, 1910), the New York Public Service Commission, First District, held that returns of 8.46%, 7.62%, 7.56% and 6.57%, respectively, upon a low valuation of the properties involved, were not unreasonable. No allowance had been made, in valuing the properties, for development expenses and other elements which should properly have been considered. The Commission held that it was not necessary in the cases before it to go further into the matter of valuation, and dismissed the complaints. The New York Commissions are now engaged in hearing some cases involving electric rates, but decisions have not yet been rendered.

28. The situation in Great Britain, where the London Sliding Scale is much in use, is of interest. Mr. W. H. Gardiner, Jr., states in his recent paper on that subject, "In England new investments in new lighting enterprises are, at the start, allowed to earn 10% on the

investment. Only after an undertaking has become well established and free from initial risks, are its future earnings lowered, by its being obliged to sell its subsequent issues of securities at auction."

29. The weight of authority is that the rate of profit is to be earned upon the present fair value of the property used in the service of the public, and not on construction cost. If a plant has been built with reasonable foresight and good judgment, and a full depreciation account has been established, the present value of plant, plus the amount in the depreciation reserve, should equal the amount of the original investment, and the original capital has been maintained without impairment. If this is not so, it indicates that depreciation has not been properly taken care of, and the rule forbids that profit should be earned on value which has ceased to exist.

30. If proper depreciation has been charged off, but the plant has been unable to earn a fair profit, such deficiency of profit properly becomes a part of the "going-value," or cost of building up the business, and the company is entitled to capitalize it, and earn a profit thereon, in later years, assuming that the value of the service will then warrant this additional charge, and that the earlier deficits arose notwithstanding good management and reasonable foresight.

31. It may be, however, that the decrease in the value of the investment is greater than any possible depreciation reserve. Conditions may have so changed, that the operation of the plant will not provide for depreciation and a fair profit. The capital has, in such a case, been impaired in spite of good management and reasonable foresight. Such a possibility is one of the risks of the business, and to be considered as warranting a higher rate of return.

32. Present value is generally reached by taking the reproduction cost, and deducting therefrom the depreciation. If an adequate depreciation reserve has been reinvested in the plant, this present value equals the original cost or investment, the depreciation charged against the same being balanced by reserve reinvested. As a rule, however, depreciation has been neglected to a greater or less extent.

33. The courts have not held definitely that the rate of return is to be computed on the basis of actual present value. They have held that the basis of the calculation is "a fair value of the property being used for the convenience of the public," and that, in order to ascertain this fair value, both the original cost of construction, and the present value, are to be considered.

34. Let it be assumed that an investment has been made by the stockholders of a utility company, upon which they are able to earn eight per cent. If the value of a certain portion of the property appreciates faster than the value of other portions depreciates, no net depreciation has occurred. If the value appreciates, it is clear that a competitor entering the field, will have to make an investment equal to the increased value of the plant already in operation. The increase in the value of the investment may be due to foresight in the selection of good localities for plant and distributing system, and to the growth of the community. Ordinarily a company cannot very well raise its rates, but if, by the increase of business at old rates or newer and lower rates, it earns a considerably greater percentage than 8% upon its investment, why is not its service worth it? And why should it not then reap the harvest of its foresight?

35. On the other hand, let it be assumed that an investment has been made of an equal amount, with apparently equal foresight and judgment, in another community. By reason of the retrogression in growth of the community, or by reason of the arrival of cheaper methods of supply, the value of the investment shrinks at such a rate that there is no prospect of the company ever making good the impairment. The selling value of the service has decreased, while the Company's costs have not. The Company cannot increase its charges, and thereby increase its rate of return, as applied to the diminished value of its original investment. A competitor, coming into the field, can successfully compete, with an investment equal to the depreciated value of the investment of the older company.

36. The possibility of such a condition is one of the risks of the business assumed by the investors. It is one which may be partially insured against by a larger rate of profit in the earlier years. It should be so insured against, wherever the value of the service is such as to carry the additional charge necessary to provide for it. If the State does not guarantee against loss where the enterprise is a failure, it should not unduly restrict the rate of profit where it is a success. The State should not seek to appropriate the unearned increment in one case, and in the other case let the undeserved decrement fall on the owners.

37. In the Consolidated Gas Company case, the United States Supreme Court said:

"We concur with the court below in holding that the value of the property is to be determined as of the time when the inquiry is made regarding the rates. If the property, which legally enters into the consideration of the question of rates, has increased in value since it was acquired, the company is entitled to the benefit of such increase. That is, at any rate, the general rule. We do not say that there may not possibly be an exception to it, where the property may have increased so enormously in value as to render a rate permitting a reasonable return upon such increased value unjust to the public. How such facts should be treated is not a question now before us, as this case does not present it. We refer to the matter only for the purpose of stating that the decision herein does not prevent an inquiry into the question when, if ever, it should be necessarily presented."

38. Another of the contingencies to be considered is the matter of the term of the franchise, under which the utility is operating. If this franchise is one similar to that known in Wisconsin as "indeterminate," and which is to continue until the municipality shall see fit to acquire the utility at a proper valuation, the franchise is an unimportant element. If the franchise fixes rates, then, like every other contract, it may have value, but the Company operating under such a franchise is not subject to rate regulation, and its rate of profit is beyond our present inquiry. If a utility accepts a short term franchise, it must be held to have done so with full knowledge of the risks involved. Such risks, however, should be compensated for, and the public, in restricting the term of the privileges it has granted, and the utility in accepting the restriction, must each be considered to have been willing to accept the burdens with the benefits. If a short term franchise is of advantage to the public, the public must be willing to allow a higher rate of return to cover the risk of unfavorable terms of renewal, or denial of renewal.

39. Certain expenditures of every public utility are unproductive. These expenditures include those made in the interests of public safety and convenience; for instance in our business, the underground construction which we have had to substitute for equally effective overhead lines. These must be paid for either out of capital or earnings. If paid for out of capital, the productive capital must earn an amount of profit sufficient to produce a reasonable return upon the aggregate investment, both productive and unproductive. If paid for out of earnings, these must be sufficient to provide a reasonable return upon the productive capital, and also to provide for the unproductive investment itself, either in a shorter or longer period of time. Of course, if paid for out of earnings, these improvements should not be capitalized, and a proper stock

and bond law will prevent such practice. In the pending investigation by the Interstate Commerce Commission into the necessity for increases in freight rates, the view has been expressed by Mr. James McCrea, President of the Pennsylvania Railroad, and by Mr. E. P. Ripley, President of the Santa Fe System (see appendix) that unproductive investment should be paid from earnings, and not be made a permanent charge in the form of capitalization. If the items of depreciation and obsolescence are fully recognized and treated as elements of cost, it would seem that it is immaterial whether this class of investments is paid from earnings or from capital. The policy of the Pennsylvania Ralroad has been to expend "a dollar for dividends and a dollar for betterments." Whatever the proper proportion may be, the present recognition of depreciation and obsolescence as proper cost items is a restatement of this rule in another and more correct form.

II—Collection of Profit from Classes of Customers

40. The reasonable profit which a utility is entitled to receive must result from the operation of its entire schedule of rates. This profit is the difference between the gross earnings and expenses, including in the latter, of course, depreciation. This profit will equal some rate or percentage upon the investment, which rate may be reasonable or unreasonable.

41. If the profit earned by the company is reasonable, it follows that its entire schedule of rates, *on the average*, is also reasonable. But this does not prove that any particular rate charged by it is reasonable. A company may be earning but a reasonable profit, and yet its rates may be open to the charge of unjust discrimination. Reasonable profit and reasonable specific rates have no necessary connection with, nor absolute relation to, each other.

42. The collection of the reasonable profit from the various classes of the company's customers, calls for the exercise of careful judgment. It is clear that the profit need not be equally distributed over each class of service. It may be proper, or even necessary, for one class of service to bear a greater portion of the element of profit than another. The law permits classification, and allows a difference in rates, where there is a difference in the cost of service, and the rates are adjusted thereto. Economic reasons warrant a different rate of return on different classes of business, provided the total resultant profit is reasonable.

43. There is no legal requirement that the element of profit in a rate to a class must be proportionate to the cost of serving that class, or must be a set percentage on the value of the property used in performing the service. Rates cannot be made by exact formula, and an attempt to distribute profit in exact proportion to the cost of serving each class, would be a practical impossibility. Moreover, the cost of the service to each class is not the only test of the propriety of different rates. The value of the service to each class is also, under the decisions, one of the tests of reasonableness, and its difference in value may or may not be proportionate to the difference in cost. Class rates are offered from necessity; they must be given to secure the business; an average rate will secure the business of the class to whom the value of the service is above this average, but will not that of the class to whom it is below the average. As soon as we reach the question of specific rates, average profits must be departed from. One class of business may legitimately bear more profit than another.

44. If two parallel railroads with the same termini, having different capital invested but equal operating costs, each hauls the same number of tons of through traffic, the aggregate amount of profit on this through traffic will be about the same. Competition between the roads will compel this condition. If the roads are each to earn the same reasonable profit on capital, it is clear that the road which represents the greater investment must earn more proportionately on its local traffic, than the road which represents the lesser investment. It is also clear that the local traffic on the former road must pay a greater portion of the total annual profit than the through traffic.

45. The same condition exists in the furnishing of electric service. The price of electric light or power to the large consumer is limited by competition, actual or potential. If the company is to serve the large user, it must do so at a rate lower than is willingly paid by the small consumer. It costs the company less to serve a wholesale consumer, and a lower class-rate is therefore justified. It is, however, not merely justified; it is given as a matter of necessity, for otherwise the company would not be able to secure the large customers. These cannot afford to pay average profit, for the service to them is not worth it. It must be offered to them at a price nearer to their individual costs. This price, of course, cannot be varied to exactly meet individual costs, for no two individual

costs are the same. It must be *a rate* offered to *a class*, and not to an individual. If figured to meet individual costs, it would cease to be a rate, and could not be distinguished from unjust discrimination.

46. A class rate must cover class cost. The cost of serving a class of customers must be determined, and a company making a class rate should be prepared to prove that the rate is more than sufficient to cover cost. There is no rule or decision, however, which requires that the profit to be earned by each class of service, shall be proportionate to the investment made to serve that class. It is clearly recognized that some business will of necessity be transacted at a less profit than other business. In other words, one class of business must carry a greater profit than another class, and a different rate of profit on well defined different classes of service does not amount to discrimination.

47. In papers previously presented to this Association, the writer has discussed the Status of Wholesale and Retail Customers, and the Status of Ordinary and Special Customers. These papers dealt with the features of competitive and non-competitive business, the various classes of service which an electric light company is called upon to perform, and the varied cost of service to these classes. It is not desirable or necessary to repeat here the discussion. This paper is dealing with the question of the distribution of profit over different classes of service. The foregoing paragraphs show that there is no exact rule whereby the incidence of profit may be determined. The following is a statement of the practical limits within which a company in making rates may lawfully apply its business judgment.

(a) No class of business should be done at a loss. As a proof that there is not a loss, rates should be so adjusted that each class of service will positively show a profit, although that profit may be small.

(b) No class of business should be required to carry an exorbitant profit. The conditions surrounding our business may usually be relied upon to keep customers from paying a rate which contains an exorbitant profit. In other words, when a class of customers readily pays a certain price for service, it may be assumed that the profit earned by the company in the performance of that service is not exorbitant.

(c) Between limits of no profit and exorbitant profit, the value of the service to the customer must guide the company in determining the profit to be earned by each class of service.

The propriety of an entire schedule of rates, or a particular schedule of rates, may be tested by determining whether it will yield a fair return; but this test will not serve to fix for a particular rate its exact position between the stated limits. This exact fixing of a particular rate is a matter of judgment, and equally so whether the judgment be exercised by the utility, or by a commission or other public authority.

48. A public utility cannot be required to serve the entire body of its customers at a loss to itself, and a rate of charge prescribed by the Legislative or an administrative body, the operation of which will deprive the utility of a fair return, is unlawful. However, a rate of charge may have been fixed which, applied to the entire business of a company, will yield a fair rate of return, but which applied to specific customers or classes of customers, deprives the company of any profit on such customer or class. The Courts have not decided that a class rate, which does not itself allow a reasonable profit, is lawful, if the company is earning a reasonable profit upon its entire business. The United States Supreme Court has expressly left the question open for future determination. In none of the cases, where the question was discussed, were the proofs clear that the company was not earning a profit under the rate complained of. A company must have different rates for different classes of service, and it is entitled to earn a reasonable profit, although not necessarily the same rate of profit, on each class. A rate of charge which deprives it of a reasonable profit on a particular class of business is confiscatory.

49. The courts have held that a railroad is an entirety, and that a rate of charge for carrying passengers may not be unfair, although it is not remunerative when applied to but one portion of its road. In the case of a railroad, however, traffic will move even at an excessive rate, unless it is more than the traffic will bear. Passenger traffic will move at rates in themselves excessive. People must travel, and will pay high rates, although grudgingly, rather than not travel at all. It is practicable for a railroad to make up for the losses incurred in the operation of one portion of its road by profits made in the operation of another. A rate which is too low on one part of the system may be supplemented by a high rate

on another part, and the resulting combination produce a fair return. This may be proper in the particular case as a matter of public policy. It may be proper for those favorably situated to share the burden of those less favorably located.

50. The same principle may apply to a certain extent in freight rates and even in electric rates. Where, however, the class of business which it is proposed shall bear the greater burden, cannot be made to pay more than its own proper share considered by itself, the principle cannot apply. In the matter of electric rates, the large consumer is in position to serve himself, and will do so, if the rate charged him exceeds the cost of his so doing, and he cannot be made to bear the losses incurred by the company in furnishing service at less than cost to the small customer.

51. We hear much of the phrase, "cost of service," and it is claimed that such cost, plus a reasonable rate of return to the company, should be the limit of charge. If this test is applied to a general schedule of rates (the aggregate returns from which will produce an amount equal to the total costs, plus the reasonable return), it is a practical test, whether or not it is the most equitable basis of rate-making. But if an attempt is to be made to apply this test to each individual customer, then, as stated, we may have as many different rates as there are customers, for no two of them furnish the same conditions.

52. Some claim that this should be the basis for the making of freight rates. These claim that the cost of carrying each article between given points should be computed, and such cost be then used as the basis for the rate. Such a basis is not only impracticable, but would result in many cases in rates so high as to prevent much traffic from moving at all. The basis of railroad rates has always been the value of the service, and while there have, of course, been errors in judgment in fixing rates on this basis, it is inherently correct.

53. In the Boston Edison Company rate investigation in 1907, the company claimed that the proper basis for electric rates was *cost of service;* that the aim should be to charge each customer substantially the cost to the company of supplying him, including a reasonable return on the investment made in his behalf. This claim was over-ruled by the Massachusetts Board of Gas and Electric Light Commissioners, which held that the cost of service to each customer was not the proper basis (see appendix). If the

cost of service to each customer (including reasonable profit) is not the proper basis of rate-making, it follows that the cost of service to each *class* of customers (including this same reasonable profit) is not necessarily the basis for class rates.

54. No better argument has been recently made against the impropriety of using a fair return upon a fair value of the investment as the sole test of the reasonableness of a specific rate charged customers, than that by Senator Joseph W. Bailey, in his address before the New York State Bar Association last January (1910) on the subject, "The Power to Regulate Transportation Charges by Statutory Enactment" (a portion of which is quoted in the appendix). In his address he used the illustration of two parallel railroads serving the same territory, each built with the same judgment and economy, but at an unequal cost. He convincingly argues that to apply the same specific rate of profit to each investment, would necessarily result in the driving of tonnage to the cheaper railroad. The illustration is used to demonstrate that the test of a reasonable rate is not a specific profit upon investment, but *just compensation* under all the circumstances.

55. The same illustration may be used in arriving at a proper solution of the question of the reasonable profit to be earned by an electric utility. If a given community be served by one central station, the latter should be satisfied with a reasonable profit, and such profit will serve as one of the factors which, together with operating costs and depreciation, will make up the schedule of rates. Where there is but one utility furnishing a given service in a community, the situation is comparatively simple, and a full and fair rate of profit can and should be included in making a schedule of rates.

56. But there may be in a given community two electric utilities, one of which has been engaged in serving the public through the various stages of the growth of the business, and with a plant not entirely up to date. The other may own and operate a plant modern in every particular, and may have been able to avail itself of the latest developments in the art. Both may be of equal capacity and may be serving in the same area. The investment of the second plant will be less than that of its older competitor. If each is to earn a specific rate of profit (say 8 or 10%) on its investment, the newer plant will unavoidably undersell its rival. If the newer plant is willing to maintain the same rate as the older one, then its profits

will be larger. If it is willing to reduce its profits, it may undersell its rival, and still earn a greater rate of profit. This situation is not a theoretical one; it exists in many places.

57. The newer plant may, as stated, be a vigorous rival located in the same area, or it may be a water power in the vicinity, which desires to dispose of its energy by bringing current over a long distance transmission line. Which investment is to determine the reasonable profit to be used in fixing the reasonable rate of charge to the public? If the newer company does not undertake to serve the entire community, but merely seeks to serve the best and most available customers, such as the long-hour customer and the large user, and makes no effort to serve the less desirable customers, what is to become of the older company, with its investment in plant and distributing system? If it meets the competition where necessary, it must raise its rates to the smaller customers, if it is to earn its specific rate of profit. This situation has been before the Massachusetts Commission in the Fitchburg and Worcester cases, and was there solved by restricting the Connecticut River Transmission Company to the sale of its current to the local distributing company, and to customers whose demand was 300 kw. or more.

58. The question under discussion, however, is upon what shall the reasonable profit be based, and how should it be distributed. The smaller customer deserves equal consideration with the larger. Cheaper investments, cheaper sources of production and lower operating cost, due to the use of larger units, should not operate to reduce the prices to the larger consumer, and raise the prices to the smaller ones. If the newer company is to be required to serve throughout the entire area, and to serve both the large and the small users, then the result is duplication of distributing investment, and a loss of the economies, which will result if the newer company is allowed to restrict its operations. On the other hand, however, if it is allowed to so restrict its operations, it will result in reducing, and perhaps destroying, the reasonable profit of the older company, unless it increases its rates to the user who is not in position to avail himself of the competition which has entered the field. The value of the service to the smaller user has not been increased because of the cheap supply available to the larger user. In fact, the value of the service to neither class is changed. The newer service is the same service, supplied, however, by a different utility company.

59. If a given rate of profit is to be used to determine the rate

of charge, which investment, the old or the new, the cheaper or the more expensive, is to be used as the basis to which the rate of profit is to be applied? Does it not appear that the rate of profit must vary, and that the older company must be satisfied with a lower rate of return than its competitor? These possibilities should be given full consideration in determining the rate of return that should be allowed to an existing company. In other words, the risks of the business should be fully considered in determining the reasonable profit to which a company is entitled; including among those risks the possibility that advances in the state of the art, the production of electric energy in newer ways and from other sources, may at any time become factors which will operate to overthrow the calculations of the most prudent, and to prove that what is today considered a reasonable profit, is not such in fact. This has been proved in the case of gas and water. Natural gas piped from a distance affected the earnings of many gas plants. New sources of water supply have made former sources practically useless.

60. Fair rates do not necessarily mean a low rate of profit. Large profits may result from just rates. As stated by Commissioner Prouty in the Spokane case (I. C. C. June 17, 1910) rates should not be reduced merely because the utility is earning large profits. In fixing a specific rate, a Commission must consider whether the result will be to deprive the utility of a fair return on its property. The purpose of such inquiry in the Spokane case was declared to be not to ascertain whether rates *should* be reduced, but whether they *could* properly be reduced, if other reasons required such reduction.

61. A rate of return merely equal to the rate of interest on money loaned on good security is not a sufficient return to those engaged in managing a business. There must be some inducement offered to the investment of capital in any business, including the business of serving the public. This was emphasized by the Wisconsin Commission in the Madison case (referred to above) where an additional percentage for *profit* was allowed over and above six per cent allowed as *interest*.

62. It occasionally happens that a new company is organized to take over a going concern, which has become inadequate to care for the needs of the community in which it is located, or it may be that a stronger organization in or near the community acquires such

going concern. The existing utility may be operating a plant and system, which has not been kept up, and has become out of date. The owners may not have kept an adequate depreciation account, or may have allowed their capital to have become seriously impaired, by taking too much out of the business in the way of dividends or otherwise. Their plant has a going value, but perhaps little more. The newer organization may be in position to successfully destroy this going value by competition, or it may prefer to purchase the plant and system of the existing organization, as the most business-like way of establishing itself in the community. Having done so, the newer or stronger organization finds it necessary to entirely discard the old plant and system, and substitute a new and up-to-date one. The original plant is thus wiped out, and its tangible value disappears. The intangible value is at once attached to the newer utility, and its value is thereby increased. It does not, therefore, have to go through the ordinary course of development in the community, or build up a new business. The courts have held that good will as such does not exist in a public service investment, owing to its being a natural monopoly. Clearly, however, the plant and system of the newer organization is worth more, owing to the fact that it is at once conducting an established business.

63. It is evident that the value of the old plant and system, thus purchased and discarded, must either be capitalized or charged off. If capitalized at the price paid for it, it must earn the same reasonable rate of profit as the rest of the capitalization which represents tangible value. If charged off, either at once or over a period of years, it will result in higher rates of charge for the service rendered. The change may be—and probably is—one that is clearly to the advantage of the community, and in such case those who have promoted and effected the change should receive a return for their energy and foresight in the shape of profits upon capitalization, which represents intangible value as well as that which is tangible. Those using the service in the community cannot afford to pay higher rates of charge than those in other nearby communities, served by the same utility, and it will in most cases be inexpedient or practically impossible to pay for the value of the older utilty, which has thus disappeared, in any other way than by thus capitalizing such value. Such capital cannot fairly be said to be water, and yet it represents something intangible, and creates a difference between the capitalization of the enterprise and the reproduction cost of the physical plant.

64. If the newer organization is serving several communities, then by capitalizing such value, which has disappeared as a tangible asset, the entire set of communities served by the utility is called upon to pay rates of charge, which will provide a fair rate of profit upon such total capitalization. However, the larger the plant and system of a utility (providing it is not trying to serve too extended an area), the more cheaply can the service be rendered to all. The same reasons which operate to make it advisable for only one utility to serve a given community, also operate to make it advisable that only one utility serve a given set of communities within a compact area; and the acquisition of an out-of-date plant in one community, and its entire reconstruction, thus operates to the advantage of all the nearby communities served by the same utility. These latter are really benefited by the change, even although a portion of the capital, upon which they must pay a reasonable profit, represents something no longer tangible. In other words, the fair value of the property used in serving the entire area or set of communities, and upon which profit must be paid, may be more than mere reproduction value. Present value may include value which is no longer tangible. The history of the development of a utility must be examined in arriving at its present value.

65. A plant and system must be built with reasonable thought for the future. If a plant is built merely for the present needs in a growing community, it represents a short-sighted policy on the part of the owners. If the owners are mistaken in their judgment as to future growth and needs, the penalty is sure. Foreclosure or bankruptcy awaits upon failure or mistaken judgment. But when the foresight is justifiable, profit should not be limited to the value of only so much of the plant as is necessary to supply the present needs of the community. There should be some reward for the risks taken by those who have undertaken to care for both the future as well as the present needs of the community.

66. The right of the owners of a utility to make up losses in building up a business has been recognized. The Wisconsin Commission, in fixing rates of charge, has allowed a utility to capitalize the difference between the past profits actually earned, and what would have been a reasonable profit in such past years (See case of Antigo Water Company, decided August 3, 1909). This is called "going value." The same principle was, as already stated, recognized by the same Commission in the Madison case.

67. If a public service company is successful, and its business prospers, its stock may command a premium in the market. Its stockholders may be able to sell their stock at a profit. The fact that the stock is worth more than par does not prove that the rate of profit being earned by the company is excessive, although sales of stock may be actually made by stockholders at the higher price, thus indicating that new stockholders are satisfied to acquire an interest in the investment at a price which will not net them the full profit being earned by the stock. A sale of stock above par merely indicates that the purchasing stockholders are satisfied with the prospects of success, have confidence in the management and in the community being served, and feel reasonably sure that they will continue to receive an acceptable rate of return.

68. Independently of statute, a stockholder has a right to subscribe for increased capital stock at par. The statutes in some states authorize the stockholders to fix the value of, and the price above par at which, the increased capital stock shall be subscribed and paid for by the stockholders. In some states the commissions have the right to fix the price, above par, at which the stock of a public service corporation shall be sold, or to require it to be sold at public auction. This authority was formerly exercised by the Massachusetts commissions, which, in cases of increase of capital stock, determine the number of shares to be sold and its offered price. Under the recent 1909 amendment to the Stock and Bond Law of that State with reference to gas and electric companies, the price is now in the first instance fixed by the Board of Directors of the Company, subject however to the approval of the Board of Gas and Electric Light Commissioners.

69. Where a company has gained such a standing that its subsequent stock issues will sell for more than par, the right of the stockholder to subscribe for such increased capital stock becomes valuable. If the law does not otherwise provide, the original stockholder has the right to anticipate that if the company is successful, he will have this right. If he sells his stock, the purchaser acquires the right. If the company is successful and the right to subscribe has value, it may be considered a proper and additional reward for foresight and good management. It is important that future stock issues of a growing company have a ready market. Experience shows that in order to market bonds, they must ordinarily be sold at a discount, or a bonus must be paid to those who underwrite them, and thus give them character as a desirable investment. This

is equally true of a stock issue, although the law does not contemplate the issue of stock at less than par. An investor is more ready to purchase a bond or stock issue that has been underwritten, than one that has not been. The cost of the guaranty afforded by an underwriting is everywhere recognized as a legitimate item of expense in connection with such an issue. The sale of stock to present stockholders at a figure somewhat less than its full market value (where such value is above par) amounts to paying them the expense which a banker's guaranty might cost the company.

70. As, however, a reasonable profit is that amount of profit which will bring to the business freely the money which it needs, it would seem proper to require increases of capital stock to be sold at market value. If the issue price is fixed by a commission, its order should provide that the stock be first offered to present stockholders at a price which will make it attractive to them, and only such stock as is not so taken should be ordered sold in the open market. A requirement that stock shall be sold in the open market in the first instance introduces an element of risk, for an unsuccessful attempt to sell stock will damage the company's credit. The course referred to will result in bringing the amount of the stock premiums into the business, instead of giving this additional value to the stockholders, in the form of a personal profit. The premium received by the company becomes surplus. The new stock receives a less net dividend than the original stock, which has carried the earlier risks of the business, and the value of the original stock is increased. The present value of the company's investment becomes greater than its capitalization. As the utility is entitled to earn a reasonable rate of return on the fair value of its property, this may result in producing a higher rate of return on the actual capitalization of such value, than on the fair value itself.

III—Distribution of Profit Between Stocks and Bonds

71. Money invested in public utilities must come: (a) entirely from the individual, or the stockholders of the company, engaged in the enterprise; or (b) in part from the general investing public, through the sale of bonds or other evidences of indebtedness. In the former case, the owners bear all the risks of the business, and in the latter case, the individual or the stockholders of a company, must bear a greater share of the risks than do the bondholders.

72. The proportion of the risk borne by each varies according to the ratio which the amount of bonds issued bears to the total

investment. If the bonds represent one-half of such investment, the owner or stockholder bears a greater share of the risks of the business, than if the bonds represent 75% or 100% of the value of the property. It is this element of risk assumed by stockholders that makes a bond issue, which represents 50% of the value of the investment, sell at a higher rate than one which represents a greater percentage. Ordinarily, the greater the margin between the amount of bonds issued and the value of the property bonded, and the less the risk assumed by the bonds, the lower the rate of interest at which such bonds can be marketed.

73. Theoretically bonds should be sold at par, and should have such margin of security, and bear such a rate of interest as will insure their sale at par during the construction period, within which it is expected to market them. A seasoned bond does so sell. The sale of bonds at less than par may indicate one of several conditions, or a combination of these conditions. The inherent risks of the business may be such that capital can only be brought into it by the prospect of large profit. It may be that the purchaser, although believing, that when the business is well established, his security will be ample, feels that the risks of the initial period of development should be represented by a discount from the par value of the bonds. He may require such a discount as will offset the fact that the bond of a new company is less readily sold, or used as collateral, than is the bond of a company having a well established business. The sale of bonds at less than par may be a concession to the ordinary desire of the purchaser for a bargain. This human element is well recognized by bond dealers, who know it is easier to sell at a discount a bond carrying a fair rate of interest, than to obtain a premium for a bond carrying a rate above the average. Whatever the reason, the marketing of bonds at a discount is recognized by the public and by the commissions as a legitimate method of providing capital.

74. By the sale of bonds below par, the enterprise is, however, deprived of the use of so much of its capital as it has been required to use for the purpose of thus paying in advance a portion of the interest on its bonds. The enterprise must earn upon the value of its tangible property, a profit equal to the interest it has agreed to pay upon the face of its bonds, plus a certain proportion of the amount of the discount at which they are sold. The discounts may, on the other hand, be capitalized and included in the going value of the business, and if this value is so capitalized, it must earn the

same rate of profit as the tangible property. The discounts on bonds may be written off in a short period, as a suspense item, and if this course is followed such amounts should not be considered part of the reasonable profit, which the utility is entitled to earn upon the value of its tangible property.

75. If the margin of security for the bonds is ample, and they will not sell at par, or subject to a reasonable discount, it indicates that the interest rate is too low, or that money looking for investment and otherwise willing to accept the rate of return offered, considers the risk too great. The element of risk determines the price at which bonds can be sold, regardless of the security behind them or the rate of interest they bear. A bond which must be sold at an unreasonable discount, is clearly not bearing a rate of return equal to the risk.

76. A bond should not ordinarily bear such rate of interest as will cause it to sell for more than par, although, of course, this is not a serious matter. The premium, however, arising from the sale should not be used as a part of the current receipts, but should be treated as capital. The rate of interest a bond should bear will necessarily vary with the character of the business, its location, and the state of the money market.

77. Under the "stock and bond laws," such as are now in force in Massachusetts, Michigan, New York and Wisconsin, bonds may be issued by a public utility only under authority of a state commission. The maximum rate which may be paid on such bonds is that fixed by the usury laws. These laws also fix indirectly the discount at which bonds can be sold, for the courts have held that bonds cannot be sold at a discount, which, when taken together with the interest rate, will amount to the payment by the borrower of more than the lawful rate of interest.

78. Under the operation of these stock and bond laws, if the bonds cannot be sold at par, or subject to a permitted discount, in accordance with the order of the state commission, a further application may be made to the commission, and a modification to its order secured, increasing the rate of interest payable. In such cases, the rate of interest, which it is necessary to pay in order to bring the money into the business by the sale of bonds, may be determined by actual test. If the bonds, with a reasonable margin of security behind them, cannot be sold within the limits of the laws against usury, it would indicate that the enterprise itself is a failure.

79. There is ordinarily, however, no such test at hand in the matter of stock issues. If a company, which has been regularly paying a dividend upon its existing capital stock, increases its capital stock with consent of the commission, those purchasing such stock do so with the expectation that the issue for which they are subscribing will continue to pay the same rate of dividend as before. If the company has a surplus, this may enhance the value of the stock, but will do so more by way of ensuring a continuation of such dividends, than by way of expectation of a share in the distribution of this surplus.

80. Capital stock can be issued legally only at par, although it may be paid for either in cash or in property. If the increased stock is offered for cash, and cannot be sold at par, it is an indication that it is not paying a dividend large enough to attract investors, in view of the risks of the business. Of course, this may also be due to other elements, for a stock may be earning and paying a fair dividend, and still not be worth par. This may be due to the fact that the value of the outstanding stock has become impaired. In such case, it may be that the order of the Commission, authorizing the increase of stock, should require this impairment to be made good.

81. A company which pays dividends not exceeding the highest contract rate of interest allowed by the statute (in a state where the rate is limited) is clearly above criticism in so doing. If its dividends are governed by a Sliding Scale plan, which lowers the price as the dividends increase, they may, without criticism, be larger than such contract rate of interest. If the capitalization of the company is not equal to the fair value of its investment, the dividends paid may furnish no test of the reasonableness of the profit thus distributed to stockholders. In many companies, particularly in Massachusetts (where stock issues are frequently sold at a price above par) the capitalization may be much less than the fair value of the investment, and a dividend apparently high may in fact be very moderate. In the case of other companies, the capitalization may exceed the fair value of the investment, and a dividend apparently reasonable may in fact be unreasonably high. The rate of dividends paid may therefore not prove the rate of profit earned by a company.

82. The risks of the business are such that a company should be allowed to earn more than the amount required to pay a reasonable dividend on a fair value of its investment. The company

should be encouraged to create a surplus, which will guarantee the credit and integrity of the plant and the service furnished, insure against contingencies, and make certain the continued payment of dividends. The importance of creating a surplus is recognized by the New York Public Service Commissions Act, Secs. 49 (Common Carriers), 72 (Gas and Electric Companies) and 97 (Telegraph and Telephone Companies), as amended and added to by Laws 1910 (Chapter 480) in providing that, in determining rates, regard shall be had to a reasonable average return upon capital actually expended, and to the necessity of making reservations out of income for surplus and contingencies. The accumulation of such a surplus has been approved by the Interstate Commerce Commission (In re advances in Freight Rates, 9 I. C. C. Rep. 382, 1903). Under the laws of Ontario, the *dividends* of a public service corporation are restricted by its charter, although there is no restriction upon the amount which it is entitled to *earn*. Some of these recent charters have restricted the payment of dividends to ten per cent. In England, dividends are quite generally governed by a Sliding Scale, and are no longer fixed absolutely. It is of the greatest importance that a proper dividend rate should be sustained, both in order to hold together the present body of stockholders, and also to make them willing to respond to new calls for additional capital as required. The rate of profit earned, however, should be greater than the rate of dividend declared, because of the great value of a continuous record of dividend payments.

83. The necessity of paying interest upon bonds, reasonably issued, has long been recognized by the courts. Recent decisions, and recent rulings of state commissions, have, however, recognized the fact that stockholders must also be given their full consideration, as otherwise there exists an inducement to issue bonds rather than stock, which would result in subjecting the utility to the payment of greater fixed charges.

84. Under the rulings of the New York Public Service Commission, Second District, the amount of bonds which will be approved by it for issue by a newly organized utility, is limited by the amount of the prospective net earnings. No bond issue will be permitted "creating an interest charge beyond an amount, which it is reasonably certain can be met from the (future) net earnings" of the company as estimated (See appendix, ruling on application of Rochester-Corning-Elmira Traction Company). Stock representing a cash investment will be required "to an amount sufficient to

afford a moral guaranty, that in the judgment of those investing, the enterprise is likely to prove commercially successful."

85. Rule XXIV of the Rules of Practice of this Commission, governing applications for authority to issue stocks, bonds, notes or other evidences of indebtedness, requires the petition to set out (among other things) in full, the terms of any contract or arrangement to sell such stock, bonds and notes; if no contract or arrangement has been made, there must be a showing by affidavit of a competent person as to the amount which can probably be realized from the sale or disposition thereof, and the reasons for such opinion.

86. Professor Howard G. Bronson, of the University of Pennsylvania, recently made a detailed examination of the investment and profits of the Illinois Central Railroad for the fifty-eight (58) years from 1851 to 1909 ("Profits of American Railways as Illustrated by the Illinois Central"—Railway Age Gazette, July 1, 1910). He states that the liabilities of that company, including stocks and bonds in the hands of the public, are less by nearly $45,000,000 than the cash value of the assets exclusive of real estate appreciation. The returns to stockholders covering the fifty-two (52) year period from 1858 to 1909 averaged 9.48% earned and 7.6% paid on cash actually invested; the difference resulting in an accumulated surplus of $50,000,000, out of a total of a little over $300,000,000. The railroad had during this period borrowed money at rates bearing from 7% down to 4% (average about 5%). The share holders had directly or indirectly furnished over one-half of the entire capital account.

87. In his testimony before the Special Examiners for the Interstate Commerce Commission at Chicago on August 29, 1910, Mr. E. P. Ripley, President of the Santa Fe System, stated that in his opinion a railroad should earn, over and above interest on bonds and other capital liabilities, not less than 12 per cent, of which not less than 6 per cent should be paid in dividends to stockholders, the remaining 6 per cent should be used for improvements which would earn no return, thus providing for obsolescence and depreciation. In his testimony before the Interstate Commerce Commission at Washington on October 13, 1910, Mr. Daniel Willard, President of the Baltimore and Ohio Railroad, declared that in his opinion a railroad stock paying less than 6 per cent was not attractive to investors.

88. The London Sliding Scale (which is much used in England in the regulation of gas rates and to some extent in the regulation

of electric rates) involves the fixing of a standard dividend and initial price; as the price of gas or electricity is reduced, the allowable dividends are increased. This standard dividend varies in England from seven to ten per cent. This principle has been adopted in regulating the gas rates of the Boston Consolidated Gas Company. The Act (Chapter 422 of 1906) is entitled "An Act to promote the reduction of the price of gas in the City of Boston, and its vicinity." It fixes the initial price of gas at ninety cents per M. and the standard rate of dividends at seven per cent; for each reduction of one cent in the price of gas, the Company may increase its dividend payments one-fifth of one per cent.

The principle of the Sliding Scale as applicable to gas and electrical companies has also been recognized by the recently amended New York Public Service Commissions Law (Section 72, 1910). It is also recognized by the Wisconsin Public Utilities Law, both as to the Company, its customers and its employes (Section 1797m-17).

89. The fact that a utility has in the past earned more than a reasonable return does not affect its right to now earn a reasonable rate of profit based on present conditions. That large profits have been taken out of the business, in the form of dividends or otherwise, does not affect the present value of the property being used in the public service. This, however, should not induce a utility to take advantage of a failure on the part of the public to regulate its rates. It should not seek to earn unreasonable profits now, with the fear that hereafter the right to earn a reasonable profit will be denied it. It should treat the public now with that same spirit of fairness with which it expects to be treated, if its rates are at any time questioned by public authority.

90. A plant may have been built largely from earnings remaining after reasonable profits have been taken out of the business, in the form of dividends or otherwise. That fact is immaterial, if these earnings have resulted from rates of charge which have not been exorbitant or unreasonable in themselves, for it is clear that the entire earnings might have been taken out of the business, and the additional facilities provided for from the sale of capital securities. It is the present fair value which forms a basis for present reasonable rates. According to modern ideas, maintenance of property and depreciation and obsolescence are strictly items of cost, and must be taken care of in arriving at net earnings. A reasonable surplus, over and above reasonable profit taken out of net earnings,

should be retained and invested in the plant. This additional investment representing surplus should not be capitalized. Its function, according to ideas now being generally adopted, is to serve as a contingency reserve to provide, without impairment of capital, or without interruption of established dividend payments, for extraordinary happenings in the way of unprecedented damages to property or of short depressions of business. The directors of the company hope that they will not have to deal with these contingencies, but as wise men take all precautions against them, it being the part of wisdom to have something in hand wherewith to meet the unforeseen.

Conclusions

91. 1:—A reasonable profit is that profit which will readily bring needed money into the business.

2:—The reasonable rate of profit is not an arbitrary rate, but will vary at different times and in different places, according to the risks involved in each particular enterprise.

3:—A rate of profit, which a court may not hold confiscatory, may not be a reasonable rate. The courts have avoided deciding what is a reasonable rate of return. The question is a legislative or administrative one. It becomes a judicial one only when a rate fixed is claimed to be unreasonable.

4:—The reasonable rate will be fixed by a rate-making body, upon an investigation of the economics of the particular situation. The courts will not fix the reasonable rate of profit, even in reviewing the action of such bodies. They will merely afford redress against an unreasonably low rate so fixed.

5:—The reasonable profit which a utility is entitled to earn must arise from the operation of its entire schedule of rates. Under some circumstances, however, the utility may have the right to insist that a separate class or classes of service carry a distinct reasonable return, and a reasonable return from an entire schedule may not excuse the lack of a reasonable return from a particular schedule.

6:—The distribution of the reasonable profit over rates for different classes of service must be done by the utility, in the exercise of good judgment, so that the resultant total profit will be adequate and reasonable.

7:—The reasonable profit cannot be distributed by exact rule over each class of business. It must be distributed according to the value of the service to the different classes of customers.

8:—In distributing profits to investors, the proportion assigned to each class (as stockholders and bondholders) should bear a proper relation to the risks assumed by each. The interest paid on well secured bonds should be lower than the dividend paid to the stockholder, who by his investment, has guaranteed the principal and interest of the bonds, while his own investment and return are subject to the fluctuations and risks of the business.

9:—Initial or temporary risks assumed by investors may properly be compensated for by returns in a form other than annual interest or dividends. The investor, who buys the bonds of a new company at a reasonable discount, is entitled to the profit accruing by the rise of his bonds towards par, as the company's business becomes established; and original or early stockholders are entitled, as a recompense for their risk and enterprise, to the increased market value of their stock, and to subscribe for new stock issues at par, if this common law right has not been modified by statute.

10:—The cost of building up a business, and acquiring an existing business in order to adequately provide for the public demands, are elements of going value, for which a utility company is entitled to credit in the determination of its reasonable profit. Such credit may be given it, either by permitting the capitalization of these costs as intangible assets, or by allowing the earning of temporarily increased returns to repay them.

11:—The reasonable return should be applied to the fair value of the property used in serving the public, as a unit, and without regard to the nature of the capitalization representing this value. The fact that bonds may bear a certain rate of interest should not result in restricting so much of the value of the plant to earning this fixed charge. If the rate of interest on bonds is less than the reasonable return upon the fair value of the entire property, the stockholders are entitled to the excess earnings as part of their share in the total profit.

12:—The reasonable return should not be entirely taken out of the business in the form of periodical dividends or otherwise. A surplus should remain to ensure the regular payment of reasonable dividends during inevitable periods of slack business. The return

in years of prosperity should be larger than the interest paid on bonds, and the reasonable dividends paid on stock.

13:—A showing that the owners of a utility have in the past received more than a reasonable profit, does not affect their right to earn a reasonable profit now and hereafter, nor should a showing that the investment represents in part past earnings, especially if these earnings have resulted from rates of charge not inherently unreasonable.

14:—If the profit is to be limited by law, economical operation should be encouraged by providing for an increase in the rate of return, proportionate to the decrease in the rate of charge for service. A fair division of benefits between the utility and the public should be encouraged by use of the principle of the Sliding Scale.

15:—The reasonableness of the rate of profit should be judged in the light of what the utility has done for the community. If the plant has been well kept up, if the rates are low, or have been gradually lowered, and the public has been given its share of the economies resulting from the progress of the art, the utility should be entitled to an increased rate of return.

Appendix

The progress of the law on the subject of Reasonable Profit will appear from an examination of the decisions in their chronological order. It was in 1876 that the United States Supreme Court decided the case of Munn vs. Illinois (94 U. S. 113), and held that state authorities had a right to fix rates for a business affected with a public interest. The court held that the rate fixed by the state authorities was absolute and final, and that the courts could afford no redress, if the rates so fixed were unreasonably low. Later decisions questioned the correctness of this view, but it was not until 1889 in the case of Chicago, Milwaukee and St. Paul Railroad Company vs. Minnesota (134 U. S. 418), that this doctrine was modified, and it was declared that a rate fixed by a legislature or a commission, if unreasonable, was illegal.

The courts have felt their way cautiously in deciding cases involving the subject of Rate Regulation and Fair Return. A distinction was drawn in some cases between rates fixed by a subordinate administrative body, and rates fixed by the legislature itself. In other cases, a distinction was made between rates prescribed for a corporation and those prescribed for an individual, and between rates fixed for a company engaged in a business clearly public, and those fixed for one engaged in a business which had become affected with a public interest from peculiar circumstances. These distinctions have since been abandoned.

I

In the earlier cases, the question before the courts was whether the right of control existed, and not the extent of the right. The courts went so far as to hold that they had no power to inquire into or interfere with, the question of the unreasonableness of a rate fixed by the legislature or a subordinate or administrative body.

Munn vs. Illinois (1876), 94 *U. S.* 113.

Chicago, Burlington and Quincy Railroad Company vs. Iowa (1876), 94 *U. S.* 155.

Peik vs. Chicago and Northwestern Railway Company (1876), 94 *U. S.* 164.

II

It was soon recognized, however, that there were limitations to the extent of the right to regulate. The courts in the following cases suggested, but did not feel called upon to define or apply, such limitations.

Spring Valley Water Works vs. Schottler (1884), 110 *U. S.* 347.

Railroad Commission Cases (1886), 116 *U. S.* 307.

III

The doctrine was finally established that a utility is entitled to a reasonable return on the fair value of its property used in serving the public, and that a rate, which restricts a utility to an unreasonably low profit, is confiscatory and void.

Regan vs. Farmers' Loan and Trust Company (1893), 154 *U. S.* 362.

Here the Trustee for the second mortgage bondholders of the International and Great Northern Railroad Company filed its bill to restrain the Texas Railroad Commissioners (Regan and others) from enforcing a certain schedule of rates fixed by them. The proposed tariff would so have diminished the earnings of the railroad, that they would not have been sufficient to pay one-half the interest on the bonded debt above operating expenses. The commissioners were enjoined from enforcing the rates as fixed. The court held that it was within its power to decree such rates to be unreasonable and to restrain their enforcement; but that it was not within its power to establish rates itself, or to restrain the commission from again establishing rates.

Covington and Lexington Turnpike Road Company vs. Sandford (1896), 164 *U. S.* 578.

This case involved the validity of a Kentucky statute fixing turnpike tolls. An action was brought against the company by users of the turnpike to restrain it from charging tolls in excess of those fixed by the statute. The company's answer set forth that the reduction ordered would so diminish its income, that it could not maintain its road, meet its ordinary expenses, and earn any dividends whatever for its stockholders. The case was heard upon the facts set up in the pleadings and upon the basis of this allega-

tion, the statute was held invalid, and the judgment of the Kentucky Court of Appeals was reversed.

New Memphis Gas and Light Company vs. City of Memphis (1896), 72 *Federal* 952.

Here the taxing district of Memphis (Tennessee) had been authorized by act of the legislature to regulate gas prices. The taxing district by ordinance undertook to fix the price at $1.50 per M. The company claimed that this rate would not enable it to maintain its existence, or make a reasonable profit on the money invested in the enterprise.

Upon application for a temporary injunction, the Court (District Judge Clark) held that if the company could by proof sustain the charges of the bill, the ordinance was illegal, as amounting to a destruction of its property, and accordingly granted the injunction. The Court said: "The company has a right to such gross income from the sale of gas as will enable it to pay all legitimate operating expenses, pay interest on all valid fixed charges, so far as bonds or securities represent an expenditure actually made in good faith, and also to pay a reasonable dividend on stock, so far as this represents an actual investment in the enterprise. All of these items and perhaps others, must be taken into account, in any regulation which may be made in respect to the prices of gas."

Southern Pacific Company vs, California Board of Railroad Commissioners (1896), 78 *Federal* 236.

Here an action was brought to enjoin the Railroad Commissioners from enforcing a certain resolution reducing certain rates, including rates on grain. The Court (Circuit Judge, afterwards Justice McKenna), in granting a temporary injunction, held that the right of the State to regulate stopped at injustice, and that rates were not alone unreasonable when they amounted to practical confiscation, nor necessarily reasonable when they allowed some dividend, however small, but that a railroad company was entitled to be reimbursed its charges and expenses, and to receive besides an adequate return on investment.

Smyth, Attorney-General, vs. Ames (1898), 169 *U. S.* 466.

This case is still the leading one upon the subject of rate regulation. In this case, the court was called upon to determine the validity of a Nebraska Act, fixing maximum freight rates. The

rates fixed were such that some of the railroads involved would under them earn on their local business only a little more than their operating expenses, while others would conduct their business at a loss.

The Court over-ruled the argument of counsel for the State (Messrs. John L. Webster and William J. Bryan) that the State could require the carriers to conduct their local freight business at a loss, if they earned on their interstate business enough to give them just compensation on all their business both interstate and domestic. The Court held that domestic business should not be made to bear the loss upon interstate business, nor the latter upon domestic business. The Court, in holding the statute invalid as confiscatory, was not called upon to say what was a reasonable rate of profit, the reductions made by the State Statute being such as to result, in the case of most of the companies involved, in no profit at all, while in the case of two of them, they permitted but little more than operating expenses.

In its opinion the Court used the following language upon the subject of "Valuation and Reasonable Return":

> "If a railroad corporation has bonded its property for an amount that exceeds its fair value, or if its capitalization is largely fictitious, it may not impose upon the public the burden of such increased rates as may be required for the purpose of realizing profits upon such excessive valuation or fictitious capitalization; and the apparent value of the property and franchises used by the corporation, as represented by its stock, bonds, and obligations, is not alone to be considered when determining the rates that may be reasonably charged. What was said in Covington and Lexington Turnpike Road Company vs. Sandford, 164 U. S. 578, 596, 597, is pertinent to the question under consideration. It was there observed: 'It cannot be said that a corporation is entitled, as of right, and without reference to the interests of the public, to realize a given per cent upon its capital stock. When the question arises whether the Legislature has exceeded its constitutional power in prescribing rates to be charged by a corporation controlling a public highway, stockholders are not the only persons whose rights or interests are to be considered. The rights of the public are not to be ignored. It is alleged here that the rates prescribed are unreasonable and unjust to the company and its stockholders. But that involves an inquiry as to what is reasonable and just for the public.....The public cannot properly be subjected to unreasonable rates, in order simply that stockholders may earn dividends. The Legislature has the authority, in every case, where its power has not been restrained by contract, to proceed upon the ground that the public may not rightfully be required to submit to unreasonable exactions for the use of a public highway, established and maintained under legislative authority.

If a corporation cannot maintain such a highway and earn dividends for stockholders, it is a misfortune for it and them which the constitution does not require to be remedied by imposing unjust burdens upon the public. So that the right of the public to use the defendant's turnpike upon payment of such tolls as in view of the nature and value of the services rendered by the company are reasonable, is an element in the general inquiry, whether the rates established by law are unjust and unreasonable.'

"A corporation maintaining a public highway, although it owns the property it employs for accomplishing public objects, must be held to have accepted its rights, privileges, and franchises subject to the condition that the government creating it, or the government within whose limits it conducts its business, may by legislation protect the people against unreasonable charges for the services rendered by it. It cannot be assumed that any railroad corporation accepting franchises, rights, and privileges, at the hands of the public, ever supposed that it acquired or that it was intended to grant to it, the power to construct and maintain a public highway simply for its benefit, without regard to the rights of the public. But it is equally true that the corporation performing such public services and the people financially interested in its business and affairs have rights that may not be invaded by legislative enactment in disregard of the fundamental guarantees for the protection of property. The corporation may not be required to use its property for the benefit of the public without receiving just compensation for the services rendered by it. How such compensation may be ascertained, and what are the necessary elements in such an inquiry, will always be an embarrassing question. As said in the case last cited: 'Each case must depend upon its special facts; and when a court, without assuming itself to prescribe rates, is required to determine whether the rates prescribed by the Legislature for a corporation controlling a public highway are, as an entirety, so unjust as to destroy the value of its property for all the purposes for which it was acquired, its duty is to take into consideration the interests both of the public and of the owner of the property, together with all other circumstances that are fairly to be considered in determining whether the Legislature has, under the guise of regulating rates, exceeded its constitutional authority, and practically deprived the owner of property without due process of law..... The utmost that any corporation operating a public highway can rightfully demand at the hands of the Legislature, when exerting its general powers, is that it receive what, under all the circumstances, is such compensation, for the use of its property as will be just both to it and to the public.'

"We hold, however, that the basis of all calculations as to the reasonableness of rates to be charged by a corporation maintaining a highway under legislative sanction must be the fair value of the property being used by it for the convenience of the public. And in order to ascertain that value, the original cost of construction, the amount expended in permanent improvements, the amount and market value of its bonds and stock, the present as compared with the original cost of construction, the probable earning capacity of the property under particular rates prescribed by statute, and the sum required to meet operating expenses, are all matters for consideration, and are to be given such weight as may be just and right in each case.

> We do not say that there may not be other matters to be regarded in estimating the value of the property. What the company is entitled to ask is a fair return upon the value of that which it employs for the public convenience. On the other hand, what the public is entitled to demand is that no more be exacted from it for the use of a public highway than the services rendered by it are reasonably worth."

San Diego Land and Town Company vs. Jasper (1903), 189 *U. S.* 439.

Here the Board of Supervisors of San Diego (California) and other counties had fixed maximum water rates allowing six per cent (the minimum statutory rate) upon the value of the plant. The valuation of the plant was attacked as too low. The evidence on this question being conflicting, the court refused to interfere.

Stanislaus County vs. San Joaquin and King's River Canal and Irrigation Company (1904), 192 *U. S.* 201.

The facts and the holding in this case on the subject of reasonable return, were similar to the foregoing case, a six per cent return (the minimum statutory rate) having been allowed.

Minneapolis and St. Louis Railroad Company vs. Minnesota (1901), 186 *U. S.* 257.

Here the Minnesota Railroad and Warehouse Commission had fixed rates for coal in carload lots. The court held that the fact that this rate, if applied to all freight, would not enable the road to pay its operating expenses, did not operate to make it confiscatory. It was also held that companies were not entitled to earn the same percentage of profit upon all classes of freight carried. As it did not appear that this rate would seriously impair the company's profits from its entire schedule, the court declined to interfere. (Same case 80 Minn., 191, 1900, affirmed.)

City of Knoxville vs. Knoxville Water Company (1909), 212 *U. S.* 1.

This was an action by the company against the city to restrain the enforcement of an ordinance fixing maximum water rates. The master's report, confirmed by the trial court, found that the rates as fixed did not permit a return of six per cent, which was the *minimum* net return which the company was entitled to earn, and the enforcement of the ordinance was enjoined as confiscatory. The City of Knoxville appealed. The Supreme Court held that there

was error in the appraisement of the value of the company's plant, and in other material respects, and reversed the case.

On the subject of reasonable profit, the Court held (p. 17) that under any aspect of the evidence the company was certain to obtain a substantial net revenue under the operation of the ordinance; that the net income n any event, would be substantially 6%, or 4% after an allowance of 2% for depreciation; that it could not know clearly that the revenue would not much exceed that return. The Court said: "We do not feel called upon to determine whether a demonstrated reduction of income to that point would or would not amount to confiscation." The results being speculative, the case was reversed, with instructions to the trial court to dismiss the bill without prejudice.

Wilcox vs. Consolidated Gas Company (1909), 212 *U. S.* 19.

This is the most recent case on the subject under discussion. The facts are referred to in the foregoing paper (Par. 20). The ruling of the court upon the subject of reasonable profit is quoted fully below (Appendix p. 168).

IV

In the course of deciding the foregoing cases, the courts occasionally reverted to the earlier doctrine of Munn vs. Illinois (1876), and held that they had no power to interfere with a rate fixed by the Legislature.

Dow vs. Beidelman (1888), 125 *U. S.* 680.

Budd vs. New York (1891), 143 *U. S.* 517 (*Three Justices dissenting*).

Since the decision in Smyth vs. Ames (1898), 169 U. S. 466, the doctrine has been settled that an unreasonably low rate is confiscation; and may be so declared by the courts.

St. Louis and San Francisco Railroad Company vs. Hadley, Attorney-General, et al. (*March*, 1909), 168 *Federal* 317 (*U. S. Circuit Court, Missouri*).

Here 18 railroad companies instituted proceedings against the Attorney-General of Missouri, and the State Railroad Commissioners to enjoin, as confiscatory, the enforcement of the 1907 statute

providing for a 2c per mile passenger rate. Under the operation of this law, allowing nothing for extra cost over interstate business, the passenger earnings from state business alone gave no return whatever to three roads, and gave returns varying from two to between four and five per cent to others. If the exact cost of service was allowed, there would be no earnings over expenses. The Court (District Judge McPherson) entered a decree for complainants, holding that the operation of the law was confiscatory under the authority of the Consolidated Gas Company case. In his opinion, the Court said: "The Supreme Court during the present year, in the case of the City of New York vs. Consolidated Gas Company of New York, 212 U. S. 19, decided that 6% was fair and right to be given to the owners upon the true valuation. My opinion is that, while a gas plant is in some respects different from a railroad, a railroad property, properly built and properly managed, should over and above expenses, make a return of 6% per annum, and considering all the evidence, the evidence fairly shows that all of these roads were properly and economically built and are being properly and economically managed, and that, after paying the expenses for maintenance and operation, there is less than 6% of returns, and not more than 3% upon any of them, and as to some of them a deficit, taking the property as above stated within the state of Missouri at its fair valuation. And this is so without reference to bonds, because in no case do the bonds bear 6% interest. But taking the business into consideration, there is still not to exceed 3% returns, and in many cases a deficit, after considering all debits and credits, upon the true valuation for the state business.

Missouri, K. and T. Ry. Co. vs. Interstate Com. Commission (*October*, 1908), 164 *Federal* 645.

Spring Valley Water Company vs. City and County of San Francisco (1903), 124 *Fed.* 574.

This was an application for a preliminary injunction against the enforcement of water rates fixed by the Board of Supervisors of the City and County of San Francisco. The Court (Circuit Judge Morrow) held that a return of 4.4% on the value of the company's property necessarily employed in the service, or 3.3% on its stock, was not a reasonable and just return, and the preliminary injunction applied for was issued.

Spring Valley Water Company vs. City and County of San Francisco (1904), 165 *Fed.* 657.

This was also an application for a preliminary injunction against the enforcement of water rates fixed by the Board of Supervisors of the City and County of San Francisco. A showing was made that under the rates as fixed, the company could not make more than 4.4% on the value of its property. This rate was held to be unreasonably low and confiscatory, and the preliminary injunction was allowed (by Circuit Judge Gilbert).

Spring Valley Water Company vs. City and County of San Francisco (1908), 165 *Fed.* 667.

This was also an application for a preliminary injunction. The Court (District Judge Farrington) held that rates of charge fixed for a water company which would enable it to earn an income of five per cent on the value of its property after all taxes, operating expenses and other legitimate and proper charges (including depreciation) were deducted from the gross income, were not unreasonable nor confiscatory. It not being clear, however, that the rates would afford this return, a preliminary injunction was issued, all compensation for water collected in excess of the ordinance rates to be impounded to await the final decision of the Court.

In discussing the question of reasonable return, the Court said (page 680):

> "The utility is entitled to a fair return, not always upon the cost of the property, because it may have cost too much; not always upon the outstanding indebtedness, because it may be in excess of the real value of the property; not always upon the total amount invested, because some portion of that which is acquired by the investment may be neither necessary nor presently useful for the public service; but upon the fair present value of that which is used for the public benefit, having due regard always to the reasonable value of the service rendered. Each case must depend very largely upon its own special facts, and every element and every circumstance which increases or depreciates the value of the property, or of the service rendered, should be given due consideration and allowed that weight to which it is entitled. It is, after all, very much a question of sound and well instructed judgment."

State Court Decisions

Brymer vs. Butler Water Company (1897), 179 *Pa. St.* 231.

Here the Court held that a water company was entitled to a rate of return, if its property would earn it, not less than the legal rate of interest; and that a system of charges that yielded no more income than was fairly required to maintain the plant, pay fixed charges and operating expenses, provide a suitable sinking fund for the payment of debts, and pay a fair profit to the owners of the property could not be said to be unreasonable.

Steenerson vs. Great Northern Ry. Co. (1897), 69 *Minnesota* 353.

Here the Minnesota Railroad and Warehouse Commission fixed certain rates for the carrying of grain. The railroad company appealed from this order to the district Court, which reversed the order of the Commission, which order was in turn reversed by the Supreme Court. The Court held that under the circumstances of the case, a net income of 5% on the cost of reproducing the road proper, and a net income of 2.5% on the cost of reproducing terminals was not unreasonable.

State vs. Minneapolis and St. Louis Railroad Company (1900), 80 *Minn.* 191, *affirmed* 186 *U. S.* 257.

San Diego Water Company vs. San Diego (1897), 118 *Cal.* 556.

This was an action to annul an ordinance fixing water rates, and to enjoin its enforcement. The trial Court held the ordinance void, but on account of errors the Supreme Court reversed this ruling. The majority of the Court held that the Company was entitled to a net compensation at least equal to the lowest current rate of interest on the basic value of its plant, properly ascertained. The minority held the Court had no power to fix any limit of just compensation, but only to inquire whether some compensation, however small, had been allowed, and that the extent of this compensation was for the municipal body to determine.

City of Grand Haven vs. Grand Haven Waterworks (1899), 119 *Michigan* 652.

Here a pumping contract had been rescinded by the Court (99 Mich. 106) and an accounting ordered as to the amount which the city should equitably be required to pay for hydrant service. In the absence of better data for measuring the compensation, the city was charged with interest and depreciation, at the rate of 8%, upon the cost to it of a plant of its own.

Cedar Rapids Water Company vs. City of Cedar Rapids (1902), 118 *Iowa* 234.

Here the City of Cedar Rapids undertook to fix water rates after the term of the company's franchise had expired. These rates were claimed by the company to be unreasonably low, and an action was brought to restrain their enforcement. The Court declined to interfere, as it appeared that the net earnings of the Company under the rates fixed by the city would amount to between 4 2-5% and 5½ on the value of its property or 6.5 on its total capital stock and bonds.

City of Chicago vs. Rogers Park Water Company (1905), 214 *Ill.* 212.

Here a city ordinance requiring the water company to furnish water free to those classes of consumers to which the city waterworks gave free service, was held void.

Long Branch Commission vs. Tintern Manor Water Company (*Nov.*, 1905), 70 *N. J. Eq.* 71. *Affirmed* 71 *N. J. Eq.* 790.

Here the municipality filed its bill to enjoin the water company from discontinuing its service. At the hearing upon the question of issuing a temporary injunction, it was agreed in open court (p. 74) that the bill should be amended by inserting a clause asking the Court to determine the question of the reasonableness of the Company's rates. This amendment was made, both parties submitted themselves to the jurisdiction of the Court, and testimony was taken, and rates fixed by the Court's order.

The Court ruled the water company was entitled to charge rates which would enable it to derive a fair income, based on the fair value of its property at the time it was being used by the public, taking into account the cost of maintenance and depreciation, current operating expenses and the right of the public to have no more

exacted than the service in itself was reasonably worth, including a fair income to the stockholders on their investment. The Court approved the rulings in Brymer vs. Butler Water Company (cited above) and Kennebec Water District vs. Waterville, 97 Maine 185, and, in applying the above rules, fixed rates which would allow the company 5% on the value of that portion of its property used in serving Long Branch, or 4% free of taxation, or between 4% and 5% without allowing anything for depreciation. The Court said: "It is quite manifest that the defendant (company) will not, under the rates which I have approved, receive anything more than a fair income on its property, even if the value of the works should be reduced considerably below the figure at which I have placed them."

Southern Indiana Railway Company vs. Railroad Commission of Indiana, 87 *Northeastern* (*Indiana, April*, 1909) 966.

Here an action was brought by the commission to enjoin the railroad companies from charging a rate in excess of that fixed by its order. The Court held that the rate of profit which the Company was entitled to earn must be determined from the facts in each case. The Court held that the order was not subject to any constitutional objections and sustained it.

Cedar Rapids Gaslight Company vs. City of Cedar Rapids, 120 *Northwestern* 966 (*Iowa, May*, 1909).

Here an action was brought to enjoin the enforcement of a city ordinance fixing gas rates. The Court held that a public service corporation was entitled to earn enough, not only to meet the expenses of current repairs, but to provide means for replacing parts of the plant when the same could no longer be used, so that at the end of any given term of years, the original investment would remain as it was at the beginning. The Court further stated that it could not say that the income of such a corporation must necessarily exceed 5% above expenses, including taxes to avoid the charge of being discriminatory. The Court said: "As the rates fixed by the ordinance are likely to yield enough above 6% per annum on the present value of the plant to cover contingencies, which may not have been taken into account, and in view of the fact that effect of the ordinance is largely speculative, we are not inclined to interfere with its operation." Accordingly the petition was dismissed without prejudice.

Coal and Coke Railway Company vs. Conley, Atty.-Gen., 67 *Southeastern* 613 (*West Va., March*, 1910).

Here the Company filed its bill to enjoin the enforcement of an Act of the West Virginia Legislature regulating passenger rates. The proofs showed (p. 644) that under such rates, the company would earn practically nothing on its passenger traffic, and less than 2.5% on its investment on its entire traffic.

The Court held that ordinarily the rate of return generally realized upon similar investments was deemed reasonable and fair and guaranteed to the investor in a public utility if he can earn it; that the rate is to be allowed upon the amount actually invested in good faith, fictitious valuations, indicated by overissues of stocks and bonds not representing actual money, being rejected; that under exceptional and peculiar circumstances, what would ordinarily be a reasonable rate of profit on the entire investment may be disallowed, as being more than the service is worth to the public.

The Court held further that the fact that a new railroad has been built without expectation of an immediate realization of a fair profit on the investment was not a circumstance justifying a disallowance of such return, if it could be earned without exaction of unreasonable rates; and that earnings, applied to the purchase of additional equipment, extensions and improvements must be regarded as part of the net earnings upon an inquiry as to whether a rate statute is confiscatory. The Court held further that stockholders were entitled to equal consideration with bondholders, there being no reason for a difference, because the investment is represented by one form of security rather than another.

The statute was declared confiscatory as applied to complainant and its enforcement enjoined until such time as it should be made to appear that its operation was no longer confiscatory.

Regulation of a Particular Class Rate

As to the effect of a regulation of rates, the result of the enforcement of which will be to compel the utility to serve for a wholly inadequate compensation a class or classes selected for favor, even if, considering the rates as a whole, a reasonable return from operations may be received. See

Atlantic Coast Line vs. North Carolina Corporation Commission (1907), 206 *U. S.* 1.

(Case involving an order requiring a railroad company to rearrange its schedule so as to make connections with through trains, when the running of the train required would impose a pecuniary loss on the company.)

State of North Dakota, Ex. Rel. McCue, vs. Northern Pacific Railway Company (*N. D.*), 25 *L. R. A.* (*N. S.*) 1001 (*April*, 1909).

Here proceedings were instituted by the Attorney-General to enforce the provisions of the North Dakota Statute establishing maximum coal rates for the transportation by common carriers of car load lots of coal within the State. The Statute was not confined to fixing rates for the transportation of lignite coal, but the coal carried being chiefly of that description, the defendant claimed that the test, as to the reasonableness of the rates fixed for the transportation of such coal, was whether the freight receipts derived from hauling it between points in North Dakota were sufficient to pay, in addition to the operating expenses of this particular traffic, a reasonable compensation or profit.

The proof showed that the lignite coal shipments formed an infinitesimal portion of the entire freight shipments in the State, and hence that the loss on freight receipts, based upon the rates sought to be enforced, would not materially affect the total receipts from all freight shipments within the State. The proof did not therefore overcome the presumption that the statutory rates were reasonable and valid.

The Court held that the proper test as to whether the rates were reasonable or unreasonable was not whether the rate fixed on the

particular commodity was sufficiently high to enable the carrier to earn a fair compensation, after allowing for the legitimate cost of transporting the same, but whether under such rates the carrier would be enabled from its total freight receipts on all its interstate traffic to earn a sum, above operating expenses reasonably necessary for such traffic, sufficient to yield a fair and reasonable profit upon its investment, and that it was within the power of the Legislature to reduce the freight on a particular article, provided the carriers were enabled to earn a fair profit upon their entire interstate traffic.

The case was appealed to the U. S. Supreme Court, where it was affirmed on March 14, 1910, 216 U. S. 579, without prejudice to the right of the Company to reopen the case, if after adequate trial of the rate in question the Company could prove that it was actually confiscatory and amounted to a deprivation of property without due process of law.

In his opinion Mr. Justice Holmes said: "The carriage of coal is a very small part of the railroad's business. The estimate of the cost is admitted to be uncertain, and to depend in part upon arbitrary postulates. * * * We do not say that experiment may not establish a case in the future that would require a decision upon the question of constitutional law, but we can express no opinion upon it now."

The decision of neither Court in this case therefore is an authority against the proposition that a rate is invalid which does materially affect total earnings, which affects a large class of a company's customers, and which can be shown to be unreasonable as to such class, notwithstanding the fact that the company may be able to earn a reasonable profit from its entire schedule of rates as applicable to all of its customers. These decisions are applicable only when the rate in question affects but a comparatively small proportion of the general business done, and its effect on profits is speculative.

On this subject see also notes in 33 L. R. A. 183, 15 L. R. A. (N. S.) 108, and 25 L. R. A. (N. S.) 1001.

Court Review

The following recent case is illustrative of the attitude of the Court towards an order made by a Commission, which it has been asked to review:

> *Minneapolis, St. Paul and Sault Ste. Marie Railway Company vs. Railroad Commission of Wisconsin*, 136 *Wisconsin* 146 (1908).

Here the Supreme Court of Wisconsin was asked to review and reverse on its merits the judgment of the Circuit Court, refusing to vacate an order of the Railroad Commission as unreasonable. The order required certain train stops to be made. The action had been brought by the railway company under the provisions of the statute, authorizing a court review of the orders of the commission, and conferring power on the courts to vacate such orders, upon the ground that the rate fixed was unlawful, or the regulation prescribed was unreasonable.

The statute placed the burden of proof upon the plaintiff in such actions "to show by clear and satisfactory evidence that the order of the commission complained of is unlawful or unreasonable as the case may be."

The Court was called upon to consider the general principles of rate making by a body subordinate to the legislature. It held that its functions were not to determine whether the rate or service fixed by the commission's order was just and reasonable, but whether the order itself was unreasonable or unlawful; and if the order was found to be such, that reasonable men might well differ as to its correctness, it could not be said to be unreasonable. It held further that in such review it was not required to exercise legislative power or to make rates; that its duties were merely to determine whether the order appealed from was unreasonable, and if so found, to set it aside, and leave the commission to take further action; that great weight should be given to the commission's order, and a very strong case must be made to establish its unreasonableness; but that, however, an order of the commission need not be confiscatory in its character and effect in order to be unlawful and unreasonable within the meaning of the statute.

* * * * *

Ex. Rel. Northern Pacific Railway Company vs. Railroad Commission of Wisconsin, 140 *Wisconsin*, 145.

Here the Court again ruled that unless the order of the commission was unlawful or unreasonable, it could not be disturbed. The case involved an order authorizing a grade crossing between two roads.

* * * * *

The Michigan Railroad Commission Act of 1909 follows closely the Wisconsin Act. But while the Wisconsin Act (Sec. 1797-m) authorizes an action "to vacate and set aside the order on the ground that the rate fixed is unlawful, or that the regulations fixed are unreasonable, the Michigan Act (No. 300, Public Acts, 1909, Sec. 92) gives the court jurisdiction, not merely "to affirm, vacate, or set aside the order of the commission in whole or in part," but also "to make such other order or decree" as it "shall decide to be in accordance with the facts and the law." The validity of this Michigan Act has not been passed upon, and it cannot be known whether the courts will undertake themselves to fix rates.

Both the Michigan and Wisconsin Acts place the burden of proof upon the complainant to show by clear and satisfactory evidence that the order of the commission complained of is unlawful or unreasonable, as the case may be. (Michigan Act, Sec. 96; Wisconsin Act, Sec. 70.)

The New York Act which creates the Public Service Commissions of that state does not provide for a court review of their orders.

Decisions by Railroad Commission of Wisconsin

In re Menominee and Marinette Light and Traction Company (*August* 3, 1909), 3 *Wisc. R. Com. Rep.* 778.

(Quoted from below.)

Hill vs. Antigo Water Company (*August* 3, 1909), 3 *Wisc. R. Com. Rep.* 623.

(Quoted from below.)

State Journal Printing Company vs. Madison Gas and Electric Company (*March* 8, 1910), 4 *Wis. R. Com. Rep.*—.

(Quoted from below.)

City of Ripon vs. Ripon Light and Water Company (*March* 28, 1910), 5 *Wisc. R. Com. Rep.* —.

Here the net return to the company was less than 6% in nine out of 14 years investigated, and in no case more than 7%. It was held that the earnings were not unreasonable, and that a horizontal reduction in rates could not be made.

In re Application of H. T. Windsor Company for authority to increase rates for electric current (*April* 18, 1910), 5 *Wisc. R. Com. Rep.* —.

Here the reasonable profit was figured at 8%.

See also cases of

Chippewa Falls Water Works (*June*, 1910), — *Wisc. R. Com. Rep.* —.

Manitowoc Electric Light Company (*June* 21, 1910), — *Wisc. R. Com. Rep.* —.

Wilcox vs. Consolidated Gas Company

212 U. S. 19

Extract from Opinion of the Court by Mr. Justice Peckham

"In order to determine the rate of return upon the reasonable value of the property at the time it is being used for the public, it of course becomes necessary to ascertain what that value is. * * *

"The value of real estate and plant is to a considerable extent matter of opinion, and the same may be said of personal estate when not based upon the actual cost of material and construction. Deterioration of the value of the plant, mains and pipes is also to some extent based upon opinion. All these matters make questions of value somewhat uncertain; while added to this is an alleged prospective loss of income from a reduced rate, a matter also of much uncertainty depending upon the extent of the reduction and the probable increased consumption, and we have a problem as to the character of a rate which is difficult to answer without a practical test from actual operation of the rate. Of course, there may be cases where the rate is so low upon any reasonable basis of valuation, that there can be no doubt as to its confiscatory nature, and in that event there should be no hesitation in so deciding and in enjoining its enforcement without waiting for the damage, which must inevitably accompany the operation of the business under the objectionable rate. But where the rate complained of shows in any event a very narrow line of division between possible confiscation and proper regulation, as based upon the value of the property found by the court below, and the division depends upon opinions as to value, which differ considerably among the witnesses, and also upon the results in the future of operating under the rate objected to, so that the material fact of value is left in much doubt, a court of equity ought not to interfere by injunction before a fair trial has been made of continuing the business under that rate and thus eliminating as far as is possible the doubt arising from opinions as opposed to facts." * * *

"There is no particular rate of compensation which must in all cases and in all parts of the country be regarded as sufficient for capital invested in business enterprises. Such compensation must

depend greatly upon circumstances and locality; among other things, the amount of risk in the business is a most important factor, as well as the locality where the business is conducted and the rate expected and usually realized there upon investments of a somewhat similar nature with regard to the risk attending them. There may be other matters which in some cases might also be properly taken into account in determining the rate which an investor might properly expect or hope to receive and which he would be entitled to without legislative interference. The less risk, the less right to any unusual returns upon the investments. One who invests his money in a business of a somewhat hazardous character is very properly held to have the right to a larger return without legislative interference than can be obtained from an investment in Government bonds or other perfectly safe security. The man that invested in gas stock in 1823 had a right to look for and obtain, if possible, a much greater rate upon his investment than he who invested in such property in the city of New York years after the risk and danger involved had been almost entirely eliminated.

"In an investment in a gas company, such as complainant's, the risk is reduced almost to a minimum. It is a corporation which in fact, as the court below remarks, monopolizes the gas service of the largest city in America, and is secure against competition under the circumstances in which it is placed because it is a proposition almost unthinkable that the city of New York would for purposes of making competition, permit the streets of the city to be again torn up in order to allow the mains of another company to be laid all through them to supply gas which the present company can adequately supply. And, so far as it is given us to look into the future, it seems as certain as anything of such a nature can be, that the demand for gas will increase, and at the reduced price, increase to a considerable extent. An interest in such a business is as near a safe and secure investment as can be imagined with regard to any private manufacturing business, although it is recognized at the same time that there is a possible element of risk, even in such a business. The court below regarded it as the most favorably situated gas business in America, and added that all gas business is inherently subject to many of the vicissitudes of manufacturing. Under the circumstances, the court held that a rate which would permit a return of *six per cent would be enough to avoid the charge of confiscation*, and for the reason that a return of such an amount was the return

ordinarily sought and obtained on investments of that degree of safety in the city of New York.

"Taking all facts into consideration, we concur with the court below on this question, and think complainant is entitled to six per cent on the fair value of its property devoted to the public use. * * *

"In this case a slight reduction in the estimated value of the real estate, plants and mains, as given by the witnesses for complainant, would give a six per cent return upon the total value of the property as above stated. And again increased consumption at the lower rate might result in increased earnings, as the cost of furnishing the gas would not increase in proportion to the increased amount of gas furnished.

"The elevated railroads in New York when first built charged ten cents for each passenger, but when the rate was reduced to five cents it is common knowledge that their receipts were not cut in two but that from increased patronage the earnings increased from year to year and soon surpassed the highest sum ever received upon the ten-cent rate.

"Of course there is always a point below which a rate could not be reduced and at the same time permit the proper return on the value of the property, but it is equally true that a reduction in rates will not always reduce the net earnings but on the contrary may increase them. The question of how much an increased consumption under a less rate will increase the earnings of complainant, if at all, at a cost not proportioned to the former cost, can be answered only by a practical test. In such a case as this, where the other data upon which the computation of the rate of return must be based are from the evidence so uncertain, and where the margin between possible confiscation and valid regulation is so narrow we cannot say there is no fair or just doubt about the truth of the allegation that the rates are insufficient. * * *

"Upon a careful consideration of the case before us we are of opinion that the complainant has failed to sustain the burden cast upon it of showing beyond any just or fair doubt that the acts of the legislature of the State of New York are in fact confiscatory.

"It may possibly be, however, that a practical experience of the effect of the facts by actual operation under them might prevent the complainant from obtaining a fair return as already described and in that event complainant ought to have the opportunity of again presenting its case to the court. To that end we reverse the decree, with directions to dismiss the bill without prejudice."

In Re Menominee & Marinette Light & Traction Co.

3 Wis. R. R. Com. Reps., 778

Extract from Opinion of Railroad Commission of Wisconsin (August 3, 1909)

Interest and Profits

"When the plants are new and conditions more uncertain, the risks are greater and the rates of profit at which capital will enter the field are usually higher. The amount which constitutes a reasonable return upon the investment may also vary with both local and general conditions. In a general way the reasonable return may be said to be that rate of return at which capital and business ability can be had for development. Theoretically it cannot be lower than this, for in that case no capital would enter the field. Under free competition it could not, in the long run, be higher than this figure, for if it was, the supply of capital for these purposes would be increased and this increase in turn would tend to reduce the rate of profits and interest. But free competition is out of the question in the case of such utilities, for they are monopolistic in their nature. It is for this reason that in the case of such monopolies the term "reasonable" has been substituted for the conditions otherwise brought about through competition. Since competition did not exist, it could not regulate, hence some other regulating force had to be resorted to. This force is implied in regulation through absolute legislation, and this regulation is guided by what is reasonable under the circumstances. To determine what is reasonable in any given case is a matter of investigation and judgment. Applied to the rate of interest, the reasonable rate is the rate that under the conditions is fair to both investors and consumers. The minimum rate, in such cases, should be limited to the rate at which capital could be had, but this rule is perhaps more applicable to new investments than to investments already made, although it is not without influence, even in the latter case. The reasonable rate of interest and profit can, perhaps, be said to be a rate that closely approximates the returns that are received upon capital invested in other undertakings where the risks involved and other conditions are similar.

Measured by this standard, these rates would be higher when the plants are new, or when the risks are greater, than later on when their business has become more firmly established. It would also be greater than the rates obtained on money invested in mortgages or in other places where the risks are comparatively low."

* * * * *

"As bonds to the extent of one-half of the value of this plant would be a safe investment security, five per cent would probably be a fair rate of interest thereon. For the stock, however, which covered the remaining half of the value of the plant, the risks would be greater but owing to the fact that the business is in the nature of a monopoly, the risks even on the latter half would be less than in ordinary commercial and industrial undertakings without such monopoly privileges. As the rate of interest or profits is largely dependent upon risks, it would seem to follow that the rate of interest should be lower in the former than in the latter classes of enterprises. This position is also strengthened when, as for public utilities, reasonable returns are recognized by law."

Extract from Opinion of Railroad Commission of Wisconsin

(August 3, 1909)

George W. Hill et al. vs. Antigo Water Co.

Interest and Profits

"Having thus determined the fair cost-value of the plant itself as well as of its business, and explained the operating expenses, the next step will consist in ascertaining what is a reasonable rate of interest and profit upon the amount so invested. These rates of return are important factors. On the one hand, they must be high enough to secure the necessary capital and business ability; on the other hand, they should not be as high as to be unreasonable to the consumers. The problem, therefore, is to find rates that, under the circumstances, are reasonable to both. Generally speaking, it can be said that they depend upon the cost of obtaining the capital and the business skill that are required. It can also be stated that, like the cost-value of the plant and its business, these rates must be determined by investigation. The conditions in this case, insofar as interest is concerned, are not, on the whole, as satisfactory as they might be, and some space will, therefore, have to be devoted to their analysis.

"The term 'interest' is well understood and needs little or no explanation. It is the amount paid for the use of capital. For the term 'profit' the situation is somewhat different, since it is used in various ways. The courts hold, in substance, that the investor is entitled to a reasonable return or reward for his enterprise, his risk and the devotion of his capital to the service of the public. The return or profit under this definition appears to include interest, or the share of the investor, as well as profits, or the share of the entrepreneur. Those who carry on the business may be investors as well as the organizers and directors of the factors of production, but this does not necessarily imply that interest and profits should not be kept separate. The older economists generally classed interest with profits. Later writers upon this subject, however, in the light of further and more complete analysis of the facts involved, have separated these two factors and have classed them according

to their nature. As interest arises from the use of capital, and profits have their source in the business ability, skill and foresight of the management, as well as in the risks assumed by it or by the entrepreneur, it would hardly seem logical to put both of these factors in the same class.

"The facts with respect to interest on the capital used are perhaps better understood than those connected with the profits. Interest is justifiable and necessary, because of the importance of capital in production, and because capital cannot be had for such purposes unless something is paid for its use. Capital in and of itself, or when standing alone, may not, in the full sense of the term, be a productive agent, but when used in connection with other factors, under the direction of a competent employer, it is one of the principal factors of production. When capital is applied in production under these conditions, it becomes the means through which a larger product is obtained at the same or at less cost than when not so applied. This, in turn, results in a greatly reduced cost per each unit of product. Without the assistance of capital the whole productive process, as it is known today, would simply be out of the question. Where the factors of production are properly co-ordinated, capital is as important and as essential as any of the other factors and is, therefore, entitled to its share of the joint product. In fact, this share must be paid or capital will not be forthcoming. Capital is obtained only through savings, and savings mean costs or sacrifices of many kinds. It represents cost; and people will, therefore, not save and permit their savings to be used in productive enterprises unless they get some return upon their sacrifices and for the risks they necessarily have to assume. But since under the conditions named, capital is productive, employers are willing and glad to pay some such compensation in the form of interest. *Interest* so paid *becomes* as much *a cost of production* as the wages that must be paid for the labor that enters into the products. These facts not only justify interest, but enable entrepreneurs to pay it.

"The cost to the entrepreneur of the capital employed is thus measured by the interest that must be paid for its use. The rate of interest, in turn, depends on the demand for and the supply of capital. When the demand is greater than the supply, the rate is comparatively high, and vice versa. The rate of interest actually paid for the use of capital, however, is greatly affected by such elements as the amount of management required in placing and

looking after the loans, and the risks involved which affect their security. Money placed in trust companies and savings banks yields about 4 per cent. Such placing of money involves perhaps the minimum amount of supervision, management and risk of any of the investments that are open to the general public, and the interest received thereon may, therefore, be regarded as net interest. Money invested in real estate mortgages, where the mortgage does not exceed 50 per cent of the normal market value, appears to yield about 5 per cent. In this case the security is usually ample, but a certain amount of management is required in placing and looking after the loans. This involves some sacrifice or cost, and this is included in the interest. In addition to this, such mortgages are not always as easily discounted as might be desirable, especially to those who, for one reason or another, may find it to their advantage to hold securities that are readily converted into cash. Mortgages covering a greater proportion of the market value of the property often bear 6, 7, and even higher rates of interest, and even at this may not find a ready market at par. What is true of mortgages is also true of securities generally. First-class railroad bonds may sell on a 4 or 5 per cent basis, while lower grade bonds, stocks, and commercial paper are usually selling at prices that yield much higher returns. From this it appears that while the net interest rate is about 4 per cent, the gross rate is much higher, varying with the work of management and with the security or safety of the investment. For a mortgage, for instance, which bears interest at 5 per cent and sells at par, the net rate is probably about 4 per cent, while one-half of one per cent in each case may cover management and risks.

"The securities of public service corporations sell at almost all kinds of prices. Bonds which do not exceed one-half of the cost-value of the plant and its business sometimes sell on a 5 per cent basis, and at other times again at prices that yield higher returns. When the bonds cover a greater proportion of the value than this, the price is lower, often so low, in fact, that the yield is from 6 to 7 per cent and even more. The prices of such securities are greatly affected by local conditions, such as the volume of the business of the plants, the character of their management, the relations which obtain between these utilities and the communities which they serve, the manner in which their finances have been handled, and on other facts of this nature.

"Securities of public utilities that are not overcapitalized ought to be among the safest of investments. Such utilities are monopo-

listic in their nature and therefore not often exposed to all the hazards of competition. The services they render are, in most instances, necessities. They are of such nature that people cannot often get along without them. Conditions are also usually such that these services can be furnished at rates that are low enough to insure takers, and at the same time high enough to cover operating expenses, including fair returns on the investment. Industries so situated are usually regarded with a great deal of favor by conservative investors. Their 5 per cent bonds ought to sell at par. This is certainly the case when the bonds amount to less than the cost-value of the plant, or for public utilities which have passed the development period and the earnings of which are ample to cover all legitimate demands that are made upon them. But such securities do not often sell at such prices. For this local conditions are often responsible. For instance, the relations between the plant and the community it serves may be strained or irritating. This relation may be as embarrassing or harmful when caused by political agitation and strife as when due to lack of tact or to arbitrary methods on the part of the management of the plant.

"When, as is often the case, the management of such plants is of the more speculative kind and expends greater efforts in selling securities than in rendering adequate services at reasonable rates, the situation becomes even more aggravated. In such cases the real value of the securities, especially the stock, is very uncertain. It can, as a rule, be ascertained only by the most thorough inquiry into the conditions of the plant, the methods of doing business, and the records of the company generally. The comparatively poor standing in the market of a large proportion of the securities of public service corporations is as much due to reckless or unscrupulous financial methods on the part of their managements as to any other cause. For full confirmation of this we do not have far to seek. It is apparent almost everywhere that securities are handled. It has aided very materially in creating a situation under which local and small investors avoid such securities when they invest their savings and in largely closing the local markets for such securities, which is a disadvantage all around, for the local market ought to be the most natural as well as the most advantageous market for them. The benefits that might accrue from having the securities placed among the people which the plants are serving cannot easily be overestimated. But such local markets, particularly among the small investors, are not likely to be more generally developed until it has

been fully demonstrated that the plants are safely and conservatively managed.

"As the bonds constitute a lien upon the property, this part of the investment is, as a rule, much better secured than the stock, which has no claim upon the assets until all the liabilities have been met. In fact, the stockholders may, within certain limits, be held responsible for the liabilities of the plant, and the stock may, therefore, become an obligation rather than a cla'm. Bonds are not only better secured than the stock, but they carry no such obligations. The risks attendant upon investments in bonds are, therefore, much smaller than in stocks. Since the risks are less in the former case, it also follows that the rate of interest thereon is lower. In the commercial world for instance, twice as high a rate of return is often required for stocks as for bonds in order that they may sell at the same price. The bondholder gets interest at a stipulated rate, no more and no less, but his claims precede those of the stockholder. The stockholder, on the other hand, receives the surplus in the business above the operating expenses, including interest on the bonds, whatever it may amount to. If this surplus is great, the rate of return on the stock may be high. If the surplus is small, then the returns on the stock will also be small. These are some of the more important differences as between the position of bondholders and stockholders. The difference in the rate or price in the two cases is almost entirely due to the difference in the risks to which the investments are exposed. The risks are also greater when the plants are new than later on when their business becomes established. That this should be the case, is perhaps natural. In the first place, there is always some doubt as to the success of new undertakings. Unforeseen obstacles may arise in the construction which tend to materially increase its cost. Mistakes of various kinds may also occur which may not only enhance the cost but result in a defective plant. There may also be doubts as to how long a plant of this kind will have to be carried before the earnings become large enough to meet the expenses. In fact, few water works pay during their earlier years, and this is also true of other utilities. Facts like these always tend to retard investments and, therefore, also have the effect of keeping interest rates at a higher level for new than for older plants.

"That interest rates are higher at first than later on is shown by the financial history of most successful public utilities and of other enterprises. In the cases of most railroads the bonds which were

issued for the first part of the construction work often bear twice as high interest as bonds that were issued since the traffic had been developed. Many of the earlier issues, for instance, bear interest at the rate of 7 per cent, and even at this had to be sold at heavy discounts, while the later issues bear interest at 3½ and 4 per cent and sell at par. Such cases are common rather than exceptional, a fact that may be learned by a simple examination of the bond issues and their prices for the various roads throughout the country. What is true for railroads in this respect is also true for the various other utilities. The rate of interest is almost invariably higher for the earlier than for later issues. The original bonds, bearing 6 per cent interest and sold at as low prices as 80 per cent of the par value, are often, when due, replaced by 5 per cent bonds selling at par. These are apt illustrations of the effect of risks upon the minds and actions of investors. Facts like these demand consideration, not only in determining the fair rate of interest in each case, but in establishing the value or amount upon which such interest should be paid."

* * * * *

"In addition to the operating expenses, including depreciation and the amount actually paid as interest on the investment, there must also be some allowance for those who carry on the business and who assume all the risks and responsibilities connected therewith. This allowance is usually called profit and represents compensation for the work of managing the business, for the risks involved and for certain other efforts. As in this case the conditions which affect profits are about normal, it will not be necessary to discuss the matter at any great length at this time.

"The amount of work required of the management depends very largely upon the nature of the business, the relation of the fixed to the variable capital, and competitive conditions. Where the proportion of current to fixed capital is relatively large and where competition is active, the duties that fall upon the management are usually more arduous than where the capital largely consists of a durable and easily operated plant, where its products or services are simple and where they are practically disposed of in a non-competitive market. Water works come in the latter class. In the case of the plant involved in these proceedings the cost of the management, as already pointed out, amounts to about $1,200 annually, and as this cost is charged directly to the operating expenses, no allowance should be made for it under profits.

"The risks, also, are much greater in some industries than in others. Where the products depend on fashions, the season, or are of a perishable character, the risks are relatively great. This is also true where competitive conditions are unrestricted. Where, on the other hand, the products or services are necessities, more durable and uniform, and where competitive conditions are restricted, the risks are relatively small. Water works supply a service that, in most cases, is indispensable. They usually have little or no other competition to contend against than such water supplies as may be obtained from wells and nearby rivers and lakes, and such competition is not often serious. But while for water works the risks from the sources mentioned are small, there are certain other risks in connection with them that should be given some consideration in this connection. For instance, in both their construction and operation many accidents may be met with and many mistakes may occur. Water works are also injured by diversions in the growth of the city in directions different from those which were expected when the plant was designed and constructed; by failure of the city to grow as rapidly as expected or as the plant had been prepared for; by failure on the part of the city to grow at all, or by actual decrease in its population and industries; by certain actions of local and other authorities through which unprofitable extensions may be required, the rates reduced and other burdens imposed, as public utilities usually have to furnish adequate service whether they are paying or not. In case of such losses, the owners are the first to suffer, as their share of the income of the plant is not fixed, but they have to take what is left after all other claims have been met. Operating expenses, taxes and interest must be paid if the plant is to run. If the earnings are only large enough to meet these outlays, the owners, or those who carry on the business, will have to go without pay. From this there is no escape. In view of these and other facts it is clear that public utilities are not entirely exempted from risks, and that, therefore, there is a speculative feature about them which falls upon those who carry on the business and for which they are entitled to something in the way of compensation."

* * * * *

"As water works, generally speaking, are among the safest of undertakings when once they have reached a paying basis, safer, in fact, than most other local utilities, the speculative gains therein should be comparatively low. This, however, does not always appear

to be the view investors take, which is evidenced, in cases like the one before us here, by the low prices at which bonds must be sold, or the high rates that must be paid for capital and loans. But while the plant under investigation has to pay rather high rates of interest, its financial condition seems to us fairly sound, and there is every reason to believe that it will greatly improve in the near future. Its earnings are on a comparatively sound basis and its securities would seem to be fairly well protected. It appears to us, that for interest and profits, when taken together, a surplus of about 7 per cent on the value of the plant and its business as here given, is probably sufficient to secure both the capital and the business capacity required, and this amount we therefore, at this time, regard as a reasonable return for these factors in this particular case.

"Industries generally, including corporations, should be fairly treated. States or communities which do not do this, will soon have occasion to realize that they are pursuing a wrong policy. A state commission, especially when dealing with rates of public utilities, should endeavor to reach results that are fair and equitable and in line with the best public policy. This is as true when considered from the point of view of the public, as when looked upon from the point of view of the utilities. With respect to the latter it can be said, that under normal conditions their rates must be high enough to leave an adequate surplus for those who assume the risks and responsibilities that are involved and to encourage new capital in entering such undertakings. Such rates, when warranted by conditions, are not only just, but necessary. Generally speaking, there is more risk in new than in older utilities, and hence it also follows that higher profits should be allowed for the former. This is in accordance with past practices and sound economic principles. As the utilities become somewhat older in the places they serve and attain to a better development of their business, the risks involved are decreasing, and with such decreases in the risks it is only fair that there should be decreases in their profits. Older and better established utilities can also secure money for extensions at lower rates than new utilities. This applies also in renewing their bond issues and other loans. In many cases they are even able to refund outstanding bond issues at much more favorable rates of interest than the rates paid in the past. In view of this it is clear that there should also be a gradual decline in the rates of interest of such plants. This is also an important fact, for it is undoubtedly the case that the rate of interest actually paid is one of the elements that

should be taken into account in considering all interest allowances on the investment.

"There is also another fact that argues for cautiousness on the part of commissions in fixing rates of charge for public utilities, and that is, that it is usually the most profitable from a social point to not restrict conditions under which business is done to such a point as to discourage undertakers from putting their best efforts into their enterprises. Man is naturally acquisitive. If you give him a chance of sharing in the benefits therefrom, he is almost certain to work hard to turn out his products at the lowest possible cost. He will, as a rule, practice economy wherever possible. For instance, he will construct his plant at the lowest cost. He will secure and keep only efficient assistants. He will make his contracts on the most favorable terms. He will adopt the best systems of management and operation. He will introduce the best machinery and methods of production wherever they are likely to result in savings. In short, he will display diligence and close supervision in every department, and in these and various other ways keep the cost of production down to the lowest possible amount. This economy of efforts, or reduction in cost, is peculiar to enterprises carried on for private gain. In fact, it is nearly always present in successful competitive undertakings, and where there is something in a pecuniary way to be gained thereby But such efforts are not likely to be put forth where no such gains are in sight. Few men like to work any harder than necessary to attain a given end. If the compensation is no greater for extraordinary than for moderate efforts, the former are not likely to be very common. In fact, they are likely to be the exception rather than the rule. That this is in accord with the facts, is often amply demonstrated by the manner in which many public undertakings are carried on. It is also, as said, in line with human nature as shown in almost every walk of life, and is also generally acknowledged to be a fact.

"These facts are extremely important, and this for the reason that, generally speaking, there is only one way in which, in the absence of monopoly features, rates or prices can be permanently reduced, and that is through a lowering of the cost of production. Reductions in this cost, for instance, may be made the means through which not only lower rates for the consumers, but greater profits for the producers are obtained. That this is the case is constantly exemplified in every day life. Since such reductions in the

cost are not likely to be had unless the employers are compensated therefor, it follows that if the rates are fixed at so low a figure as to prevent all compensation of this kind, the opportunities for rate reductions will also be decreased. If the rates of public utilities are kept at so low a point as to offer no chances of any kind for any returns to the owners above those which are absolutely necessary to keep the plant running, it is also almost certain that all progress in these industries will be greatly retarded, and that the interests of the public will be less well served in the end than if a more liberal policy with respect to rates had been adopted.

"But the customers of public utilities should also be fairly treated. The customers are entitled to adequate service at reasonable rates. They should not be charged monopoly profits nor be burdened with the bad and inequitable results of discriminatory rates. The owners of such utilities assume important responsibilities towards the public, and these should be met to the best of their abilities. Managers of these utilities who adopt a policy that is indifferent, if not absolutely arrogant, disregarding even reasonable demands on the part of their customers, are, in the long run, almost certain to be losers from this course.

"All of these facts are of the greatest importance and should be given the fullest possible consideration in all cases where questions as to rates and services are involved. In fact, a commission in fixing such rates and passing upon the services rendered, should take all facts and conditions into account. It should be as much guided by the ultimate as by the temporary interests of both the utility and its customers.

"If the preceding analysis of interest and profits, or of the part which capital and the employer play in modern production or in the services rendered by public utilities, is even approximately correct, then it also follows that *interest proper* should include only the amount that is paid for the use of the capital employed; that profits consist of the wages of management, broadly interpreted, of compensation for the risks and responsibilities that must be borne by the employers, and of such other compensation, if any, as may be demanded by the conditions; that each of these elements, in the long run, must be high enough to attract capital and business ability into such utility enterprises; and that it is the duty of the commission, in passing upon matters in which interest and profits are involved, to determine in each particular case how much is to be allowed for each of these elements."

Extract from Opinion of Railroad Commission of Wisconsin

(March 8, 1910)

State Journal Printing Co. vs. Madison Gas & Electric Company

Interest and Profits

"While public utilities are subject to many conditions that tend to increase the risks under which their business is carried on, they are also afforded a great deal of protection that is of considerable value to the investors. This protection has its source partly in legal provisions, and partly in the fact that, after all, such utilities are natural monopolies and are engaged in furnishing services that have practically become necessities and for which there appear to be no effective substitutes. While the investors in gas and electric light plants are exposed to certain hazards or risks, these risks, while greater than the risks which obtain for money placed, say, in trust companies and good mortgages, are not, on the whole, as great as those which obtain in ordinary competitive enterprises. This is as true for the plants involved in these proceedings as for such plants generally.

"The rates of return upon the investment are usually divided into interest which goes to those who furnish the capital, and profits which go to those who assume the responsibility and direction of the business. The rate of interest depends on the supply and demand for capital and is, therefore, lower where the risks are low and where the troubles involved in looking after the investments are small, than where these elements are greater. That this should be the case, is only natural, for few are willing to assume risks and responsibilities unless they are compensated therefor in some form, or unless the prospects for such compensation are fairly good. There are other factors than those given which also affect the rate of interest, such as the readiness with which the money may be withdrawn, the location and nature of the industries, etc., which have been fully described in other decisions, but these are, perhaps, in most instances of smaller importance. Money placed in savings banks, trust companies and good mortgages yield from about 4 to about 5 per cent. In the case of such investments the risks are very small and they

require but little care or trouble. These rates consist mostly of pure interest and can, perhaps, be regarded as the minimum rates that are obtained by the ordinary investors. Money invested in good bonds for which there is a ready market bring no more than the above rates, if as much. Bonds and mortgages of a somewhat lower grade yield from 6 per cent up to 8 per cent or more, and commercial paper brings from 6 to perhaps 10 per cent or better. In fact, there are such variations in both the character of the investments and the rates they yield, that it is difficult, if not impossible, to properly classify them.

"The bonds of the company involved in the present proceedings which, as already pointed out, amount to about $400,000, covering less than one-half of the value of the plants, bear interest at the rate of 6 per cent and sell at from $106 to $108, thus yielding about 5.6 per cent on their price. These bonds are amply secured, being backed by the entire value of the plant as well as by its earnings, which show a surplus above the operating expenses and depreciation that is several times as great as the amount required to meet the interest charges on these bonds. If this bond issue had equaled the cost of the physical property of these plants, the chances are that they would sell at even less than par, and this regardless of the fact that, because of the connections of the owners of these plants, their securities had an unusually well developed market. There are also certain debentures outstanding against these plants which bear interest at 7 per cent. As these debentures do not appear to be quoted in any of the regular markets, we are [un]able to give their market value; while they bear a higher rate of interest than the bonds and would seem to be about as well secured, they do not constitute the first claim upon the assets of the company, and it is therefore not likely that they would sell at any higher prices in the market than those commanded by the bonds. These facts are important, because they indicate that the actual rate of interest on the capital invested in these plants does not appear to be far from 6 per cent.

"Interest is justifiable because of the importance of capital in production, and necessary because without it capital cannot be had for industrial and commercial purposes. The rate of interest, as determined by economic forces over which individual borrowers have little or no control, and the effect of these forces, are often best measured by the prevailing rate in the various undertakings where money is obtained on the best terms that can be had. These terms,

in such cases, usually take into account the risks involved, the trouble of looking after the loans, the readiness by which the loans can be converted into cash or withdrawn, and other factors that affect the rates of interest. In this particular case the position of the plants, with reference to the risks involved and other factors when compared with similar factors in other industrial enterprises, appears to be about the same as those which obtain, with reference to the rates of interest which these plants pay, when these rates are compared with the rates of interest in other industrial enterprises. The conclusion, therefore, must be that, for the purposes of this case, it would hardly be fair to place the rate of interest alone at much of anything below 6 per cent on a fair valuation of the plants.

"The profits of a business consist of the balance between the sum of all expenses and the total income of a business. In other words, it is made up of the difference between the sum of the rent, interests, wages, and other items, such as taxes, etc., and the total gross receipts. This difference is the last share of the total income, the share of that factor or of those who, in the full sense, are responsible for the enterprise. This share, like the other shares, is not fixed. It simply consists of what is left after all other claims have been satisfied. Rent and interest are usually fixed at a certain rate annually, and this, in a sense, is also true of wages, salaries and other expenses. At any rate, these amounts are fixed in advance and are paid by the employers or by those who carry on the business, out of the gross receipts. The amount left, however, after these shares have been satisfied, belongs to the employer and represents his share, or the profits of the business. If the balance left for such profits is large, then the rate of profit is also large, and vice versa. In some cases the profits are figured on the sales or on the turnovers; in other cases, again, on the year; but the most common basis of measurement is the investment, or the same basis as that upon which interest is measured. Interest and profits are thus often measured upon the same basis, and one reason for this would seem to be found in the fact that earlier writers on economics did not always draw any clear distinctions between these two elements.

"Before the advent of the modern corporation and the present facilities for credits, the capitalist and the employer were one and the same person. Business undertakings were then carried on in comparatively small units. The employer himself furnished all the capital, managed the business, and assumed all the risks. In other

words, he performed all the functions for which interest and profits are received. Since the functions of both capital and the employer were united in the same person, there was, in actual practice, no very good reason for separating the shares or compensation of these two factors. Since the advent of corporations, systems of credits and other modern conditions, all this has changed. Today those who have capital, but do not prefer to risk it in their own business, usually loan it to those who have business abilities and are engaged in industrial enterprises, and who are willing to pay the current rates of interest on such loans. Since the business units have grown so large as is the case at present, it is usually found that those who have the capacity for the successful operation of a large undertaking, but who lack all or a part of the capital needed, therefore, are much more numerous than those who have both such capacity and the requisite capital. Hence, a condition has developed under which business is largely carried on with borrowed capital. Those who furnish the capital receive interest thereon. Those who borrow it and who use it in their business pay this interest, and, as compensation for their services of management and the risks they assume, receive profits or the surplus above the expenses.

"This does not mean that employers, as a rule, have no capital of their own in the business they are carrying on, for most of them have more or less of their own money invested therein. It simply means that, as a rule, the business they are doing is much too large for their own means, and that they therefore find it necessary and economical to use the capital of others as well as that of their own. This has led to a separation of the functions of the capitalist and the employer. The investors or capitalists are treated as a class by themselves. The employers, or those who assume all the responsibilities for the management and the risks of the business, are treated as a separate class. To the extent the employers are investors in their business, they are also regarded as capitalists. In the employers more than one factor of production is thus combined, and they usually share in the proceeds of the business to the extent of each of these factors. The employers simply borrow from the capitalists such money as they may need, and for the use of this money pay stipulated rates of interest which vary with the lenders' estimate of the security of the loan. This money, together with their own money, the employers use in their business. Such borrowing simply amounts to this, that the employers assume the control and risks of these loans until they are paid back. The employer is,

in fact, the owner of this money in the meantime. He pays interest thereon and also pays all the other expenses of the business. The balance left after all expenses have been met, if any, is called profits, and these profits constitute the employer's compensation for his services. These are, in the main, the facts which have caused later writers on business and economic topics to enter upon a more complete analysis of the functions of capital and the employer, and of the compensations which each of these two factors receive for the part they play in producing, marketing and selling the products.

"Present views upon these matters also appear to be in line with the facts which have thus been briefly outlined. Profits are now acknowledged to be a peculiar form of income which, while they differ from rent, wages and interest, occupy about the same rank when it comes to their fundamental importance. Profits are a surplus over and above the expenses of production. They are usually identified as the balance left over after the claims of all other factors have been satisfied, and as the income that goes to those who carry on the business. Those who carry on the business, or the employers or entrepreneurs, as they are usually called, are regarded as co-ordinators of the factors of production, and as the assumers of the risks and responsibilities of industrial undertakings. In other words, the employers under modern conditions assume, on their own responsibilities, the difficult but important tasks of so directing the work of manufacturing, marketing and selling the products that any given amount of efforts may be most effective in supplying human wants.

"The work of the employers may, in a general way, therefore be said to consist of bringing together the labor and capital that may be required; of arranging or laying the general plan of the business; of determining what is to be produced as well as the methods of production; of finding the market and arranging for the sale of the products; they superintend or watch the carrying out of their plans, sometimes in a more general way only, but often in detail, depending upon the volume and the nature of the business; and in addition to this they also assume the risks that are involved in their undertakings. In other words, they are the general directors, and risk takers of their businesses. Their functions are, in fact, so numerous and varied that it is impossible in a brief space to even mention them all. They could easily be separated into several distinct classes.

"What is true with respect to the varied character of the work of the employers, is also true with respect to their compensation for this work. While this compensation, when considered as a whole, is called profit, it could undoubtedly, upon sufficient analysis, be divided up into as many classes as the work. To do this, however, is very difficult. Profits, being a surplus, are not determined by any one set of principles. They are the result of the many forces that affect the prices at which the products sell as well as the cost at which they are produced. In a general way, however, it can perhaps be said that profits are made up of the wages of managements, of speculative gains from the risks which have to be assumed, and of gains such as depend on chance rather than foresight, and of gains due to power of bargaining and other conditions of this nature, including monopoly powers.

"The wages of management and superintendence are often included in the operating expenses. This is especially true of public utilities and of most other corporations. When the wages so paid include full compensation for such technical skill and ability of management, including the work of planning the operations and their ultimate direction as may be required, and when this compensation is included in the operating expenses, then it is also clear that it should not also be included elsewhere among the outlays or under any other head. Thus, if the cost of both superintendence and management is included as wages or salaries in general expenses, the balance between the outlays and the receipts of a plant need not be large enough to cover these costs. There are many cases, however, where all of these costs are not charged directly to what is termed the cost of operation. Superintendence, for instance, may be charged to this cost, while management expenses may be cared for out of profits. Again, a part of these items may go into operating expenses and the remaining part into profits. Practices in this respect vary greatly, not only as between industries, but as between different plants in the same industry. Since there are variations in the manner in which these costs are treated, it also follows that before any hard and fast conclusions are drawn from the figures given in the financial reports of such enterprises, it is necessary to determine their practices in this respect. The amount of work falling upon the management depends largely upon the investment, the amount of business that is done and the nature of the same. While there are great variations in this respect, it can, perhaps, be said that the amount of management that is re-

quired in a business depends more upon the circulating than on the fixed capital. In industries where the proportion of the former is relatively large, the work of the management is also relatively heavy and vice versa. As the cost of the management bears a somewhat close relation to the work, that is required of it, it also follows that this cost is comparatively low where by far the larger proportion of the investment consists of a durable and easily managed plant which requires but little attention after it has been constructed and put in operation. Public utilities come in this class. In these the cost of the management constitutes only a comparatively small part of the total cost of the investment, although this is not always the relation that exists between this cost and the value of the products of such utilities.

"Abilities of the highest order are often required for the successful operation or management of a business enterprise. In many industries really effective superintendence requires the highest technical skill and training. When it comes to the management proper, so much may not be needed in the way of technical skill, but other qualities are often required that are even rarer. A manager, particularly if he is producing for the general market, must, first of all, have a thorough knowledge of everything that concerns his own business. He must have the power of forecasting the future, of foreseeing the broader movements that affect both production and consumption; of seeing where there are opportunities for supplying, if not for creating new wants; of being able to improve old methods of production as well as the products that are made for the market. The manager must be a good and cautious judge not only of the present, but also of the future. In addition to this he must also be a leader of men, able to choose efficient and conscientious assistants whom he can trust and rely upon, as well as of interesting them in their work so as to bring out the best there is in them. While doing all this, he must be able to exercise general control and to see to it that the main plans are adhered to in the business as a whole, and to so engineer the different processes that the products are turned out at costs that are low enough so that they may be sold at profits. All this requires a high order of ability, judgment, tact and determination, qualities that are, perhaps more dependent upon natural capacity than upon technical training. There are, of course, many industries which are operating under favorable conditions and where the duties of the employer are less exacting. The products they supply are simple and require little

change. The methods by which they are produced are uniform, well settled and do not require the highest technical skill. The markets in which these products are sold are also well established and defined. In such cases the operation of the plants is often reduced to merely routine work. This is the situation for some of the public utilities and for many other undertakings.

"While the work of the management is among the highest classes of work that is performed in connection with any enterprise and often requires the greatest ability in order to attain success, it is a fact that managerial ability is not as scarce as may appear to be the case at the first blush. In our present commercial and industrial processes a class of men are constantly being developed who appear to be quite able to fill these positions as they become vacant or are created. The result of this is, that the supply of almost all grades of managerial ability is, in most cases, equal to the demand. In view of these facts it is also obvious that the cost of this class of service is a matter that is not entirely independent of ordinary competitive conditions.

* * * * *

"Whether the executive expenses in this case are unreasonably high, is something that can be determined with only approximate accuracy. In passing upon this question the size of the plants, their earnings and expenses, the conditions under which they are operating, the grade of men required for safe and effective operation, are all matters that should be carefully considered. The larger the plant the more numerous the customers, the more is required of the management. High-grade service safely rendered may also require greater efficiency on the part of the management than if the standard of the service were lower. When the salaries are fixed with these conditions in mind, and no more is paid than the amount that is sufficient to insure proper and efficient service, there is little to be said regarding the salaries paid. If, on the other hand, the salaries are kept at an unreasonably high level in order to cover up earnings, or for some other reason of this nature, there may be good ground for criticisms.

* * * * *

"As already pointed out, the greatest risks usually prevail in competitive undertakings. In these there is a constant struggle between the competitors to reduce the cost of production and to

bring about other changes that will give them some advantage in the markets. Such producers have no way of controlling the supply of their products; and since the prices of the same are therefore beyond their control, they are apt to suffer from any improvement in the method of production on the part of any of their competitors that tends to either reduce the cost of these products or to enhance the demand for them in the market. The uncertainties or risks that are arising from these and similar sources are often extremely great. Even the ablest and most foreseeing of the producers are often taxed to the utmost in holding their own in the market. In cases where they are protected by patent rights or enjoy other advantages of this nature, the risks are, of course, somewhat reduced. But the security which is derived from such sources is not permanent. Patent rights expire. Improvements, both in organization and in methods and machinery, are constantly going on. Advantages of this kind are, therefore, apt to disappear at almost any moment.

"In industries where certain monopoly conditions prevail, such as public utilities, competitive risks are, of course, of much smaller importance. In such industries the supply is under control and there is no direct competition in the sale of their products or services. There are, of course, exceptions to this, but these are not frequent, nor often serious or permanent. But when direct competition exists between such utilities, it is in the very nature of things most destructive. It means serious losses to all the competitors, and if continued for some time, ruin to one or the other. It is for these reasons that such competition is usually short-lived, and that it soon ends either in the consolidation of the competing companies or in agreements between them of some sort, under which prices are restored and maintained. But, as said, such conditions are now not very frequent. Water works have little or no other direct competition to contend against than such water supplies as may be obtained from wells and nearby rivers and lakes, and such competition is not often serious enough to materially affect conditions. This is also, in the main, true for gas and electric companies, although these compete some as between each other. When they have exclusive franchises, they can meet with no direct competition, and even when their franchises are not expressly exclusive they are often practically so in effect. Both may suffer some from such substitutes as oils and acetylene plants, but even such competition is seldom met with as long as rates are held down to reasonable limits.

Gas and electric current used for power, have, of course, to contend against each other as well as against steam, but the seriousness of this is usually materially reduced by the fact that each, to a certain extent, has a field of its own to supply. That is, there are certain demands for power in each case that are best served by one or the other of the utilities mentioned, or in which each has some advantage over the other. In considering everything, therefore, these utilities do not appear to be as great sufferers from either direct or indirect competition, as is the case in most competitive undertakings.

"But there are, in public utilities as well as in other industries, other than competitive risks. In the construction and operation of such plants many accidents may be met with and many mistakes may occur. While some of these might have been foreseen and prevented, others may be beyond human intelligence and grasp. Many examples of this might be mentioned. Such plants may also be injured by the diversion of the growth of the city in a different direction from that expected when the plants were built; by the failure of the city to grow as rapidly as expected or as rapidly as the plant had made preparations for; by the failure of the city to grow at all, as well as by decreases in its population and industries; by actions of the local and other authorities by which unprofitable extension may be required, the rates reduced or other burdens imposed, as public utilities usually have to furnish adequate service whether it is paying or not. In the case of such losses the owners or employers are the first to suffer, as their share of the proceeds is not fixed, but has to take what is left after the other claims have been met. Wages, salaries, supplies, taxes, interest on the bonds or notes, etc., must be paid by the employers or the business will stop or go into receivership. If the earnings are only large enough to cover these outlays, the employer will have to go without his pay. There is no escape from this. In view of these and other facts, it is clear that public utilities are not entirely exempted from risks and that, therefore, there is a speculative feature about them for which their owners are entitled to something in the way of speculative gains.

"To state even approximately what the speculative gains or the compensations for the risks which employers assume for society should amount to in the various industries, is, of course, difficult. The data so far collected upon these points are not as complete as they might be. Comparatively few enterprises issue regular reports showing their earnings and expenses in detail. Those which issue such reports usually show the total profit in a lump sum, making

no attempts to separate this item among its constituent elements. In fact, the classification of the various property earnings, expense and other items on the records of most enterprises is quite likely to differ from the classification of these elements by economists. But while all this is true, it is nevertheless a fact that there are few elements in any business concerning which a fairly reliable information cannot be had if the proper efforts are made to obtain them. A close study and observation of the actual facts in the business world, as well as of the reports in which the results of the various business operations are summarized, can hardly fail to throw a great deal of light upon questions of this character.

"In monopolistic industries the average profits are often greater than in competitive ones. That this should be the case is only natural, for the former control the supply of their products and are, therefore, quite generally in position to charge such prices for the same as will yield the greatest net returns. In fact, the chief peculiarity of monopoly prices is found in the control which monopolies have over the supply. In other words, the former are governed through the control of the latter. In competitive industries the magnitude of the profits depends on the managing ability, foresight, bargaining skill and good fortune of the employers. In monopolistic industries profits rest on these qualities as well as on an additional element which is of the greatest importance, namely, the ability of the monopolist to control the supply, which usually results in fixing prices at the point where, as said, they will yield the highest net profits. Competitive profits tend towards the minimum; monopoly profits tend towards the maximum. The latter profits are also apt to have greater stability than the former. This applies, in varying degrees, to all kinds of monopoly advantages, or to public utility corporations as well, to good will, patent rights and other privileges of this character.

"Regardless of these facts, there appear to be many enterprises of a monopolistic nature, such as public utilities, that are not even earning the average profits, but are actually losing money from year to year. That this is the case is clearly shown by their financial reports and records. In some instances, this is due to lack of customers, or to the fact that the places where the utilities are located are too small to furnish the requisite number of customers or volume of sales that are necessary for a paying business. In other cases, again, it is due to such adjustment to the rate schedules that the

proper extension of the business is effectively prevented. In still other cases it is found in the fact that the rates charged are too low to yield a profit. This is sometimes the case when the rates are fixed by the municipality. In some cases such losses are, therefore, due to conditions that may be removed through more efficient management and more equitable rate schedules, while in other instances they seem to be beyond remedy until the places which the utilities are serving have attained their proper growth of development.

"But while many public utilities are losing money, there are also a great many of them that are making good profits. While these profits are not often as large as appears to be the general belief, they are often above what appears to be the average run of profits in many other industries. A close examination of a great many financial reports show that, while some utilities are not earning their operating expenses, including the wages of management and interest on the investment at current rates, others are earning a great deal more than this. The present situation, therefore, is, that the speculation and other gains vary from nothing up to sums that amount to several per cent on the investment. Just what the average speculative gains of gas and electric plants amount to at present, is, therefore, a matter that is difficult to estimate. Where such gains actually exist, they appear to amount to sums that vary from 1 to 10 or more per cent on the investment. When interest on the investment is figured at 6 per cent, there are plants that show a surplus above this that runs up to about a like amount on what appears to be fair valuations of the plants. As gas and electric plants, generally speaking, may be regarded as fairly safe enterprises, especially after they have once reached a paying basis, safer in fact than many competitive undertakings, the speculative gains in the former should also be measured by a lower standard than those which prevail for the latter. While this is true as a general proposition, it does not apply in every case, nor is it always the view investors take of it. The plants in question here, however, are favorably situated. Their earnings appear safe and are gradually growing larger, and they enjoy fairly good credit, which is indicated by the prices at which their bonds are selling.

"The processes of the equipment involved in producing and delivering gas to consumers are usually assumed to be more fully developed and subject to fewer changes than the processes and equipments that are involved in producing and delivering electricity. As these assumptions appear to be in accordance with the facts, it

would also seem to follow that the risks involved are somewhat lower for gas than for electric plants and that, for this reason, the latter kind of plants are entitled to somewhat greater profits than the former. Just what this difference should amount to, is a question that largely depends upon the conditions in each case and concerning which no general rules can be laid down that are likely to amount to a great deal.

"In view of the facts that have thus been presented in relation to this subject, it may be said that the witnesses for the respondent placed that part of the return on the investment which might properly be termed profits at rather high figures; and that under the circumstances in this case it is not unreasonable to limit the profits to from 1½ to 2 per cent on a fair valuation of the gas plant and from 2 to 2½ on a fair valuation of the electric plant. Such rates, in addition to an allowance of 6 per cent in each case for interest, would seem to be fair to the present owners as well as sufficient to secure both the business capacity and capital that are required in this particular case. It would not be unreasonable to limit the returns for both interest and profit to not less than from 7½ to 8 per cent on a fair valuation of the gas plant, and to not less than 8 per cent on a fair valuation of the electric plant.

"Profits often also contain other elements of gain, such, for instance, as are derived from unforeseen and fortuitous circumstances and from superior power of bargaining. The former of these two classes of gains would rather seem to be the result of chance. They depend upon sudden changes in the demand, temporary shortages of goods on the part of competitors, and other conditions of this nature, rather than on foresight and good business judgment. Such gains, nevertheless, are often of considerable importance and may be of material aid in the success of an enterprise. The gains of bargainings are also often of the greatest importance. They consist of the ability to buy at the lowest and sell at the highest possible prices. In actual practice it often happens that the shrewder one of the bargaining parties can sell for higher than his lowest price and buy for lower prices than those he might have been ready to pay, and that his advantages in these respects are simply due to the fact that he has the ability to derive the closest bargains. These powers may be due to greater natural capacity, to better and more complete information upon the matters involved, and to several other causes. In any event, it is a valuable power to possess, as it frequently leads to considerable increases in the profits of a business.

"In passing upon these matters, however, it should be borne in mind that under present industrial conditions the best interests of society, as a whole, are subserved when the share of each factor of production is high enough to cause a free and unrestricted flow of labor, capital and business ability into the various utilities. If wages, interest and profits are not high enough to attract the factors which they represent, then these factors will not enter the utility business. The result of this is clear. If either or all of the factors refuse to enter this field, then no service of the kind these utilities render will be furnished, and the people may have to forego what may have become necessities to them. In order to obtain such service, therefore, it is absolutely necessary that the wages paid should be high enough to attract competent workmen, superintendence and management; that the interest paid on the capital legitimately invested should be sufficient to attract the necessary capital into these enterprises; and that the speculative and other gains should be high enough to induce employers to enter these industries as coordinators of the other factors of production therein and as assumers of all risks and responsibilities that are involved in their operation. From these facts there is no escape. From this it also follows that the rates fixed for the services rendered by such utilities must, in the long run, be high enough to attract the various factors of production, or to induce the employer to enter upon such enterprises and to become responsible for the risks that are involved."

Extract from Opinion of Massachusetts Board of Gas and Electric Light Commissioners

In re Charlestown Gas and Electric Company's Gas Rates

On June 27, 1910, the Massachusetts Gas and Electric Light Commission made an order reducing the price of gas sold by this Company from ninety cents to eighty-five cents, the reduction to take effect August 1st, 1910. The price of gas furnished by the Boston Consolidated Gas Company was eighty cents, and that sold by the Cambridge Gas Light Company was eighty-five cents. Both the Charlestown Company and the Cambridge Company had been paying annual dividends of ten per cent. The outstanding capital stock of the Charlestown Company was greater in proportion to its output than that of the Cambridge Company, and was also larger in proportion to book values, and apparently to the actual values of their respective plants.

In its decision the Commission said:

"The decisions of the courts seem to establish clearly that a company's reasonable rate of profit is not to be based upon the volume of its outstanding securities. but is dependent rather upon the actual value of the plant devoted to the public use. Whatever may be a fair and reasonable rate of return to either company on this basis, it does not necessarily require that it must be sufficient to maintain the same rate of dividend in both. The Cambridge price and dividend, made as they are voluntarily by the company, may be assumed to be not unreasonably low. The Charlestown dividend is only fair when it can be earned with a reasonable price. Under most conditions a fair and reasonable rate of dividend is a very important factor in determining a reasonable price. Under other circumstances other factors may be of greater importance.

"In an inquiry like this, the board must determine what price is reasonable, not merely for the stockholders, but for the public, in view of all the circumstances surrounding the case. The public is in any case entitled to the lowest reasonable price at which a company can afford its service, irrespective of prices elsewhere. But this is not the only rule to be considered, for in process of time and under some conditions, a certain standard of prices may become so well established, that a company may be bound to meet it, even though such action may involve some risk to the continuance of a well-established and otherwise not unfair return. Although companies of this class may exercise a practical monopoly within their respective areas of supply, they are not wholly relieved from the competitive

force of rates elsewhere. The reason which apparently led the Charlestown company to reduce its electric prices, both for public and commercial lighting, to the level of those in other parts of Boston, are a virtual recognition of the truth in these propositions.

"In view of the decrease in the company's electric income and the increase in expenses already noted, a reduction in the price of gas may have some temporary effect upon the present rate of dividend. It may, nevertheless, be confidently expected that the price named will yield under all circumstances a reasonable return upon the value of the property which the company is employing for the supply of gas in the territory which it serves. The board is not convinced that under present conditions the Boston price is a reasonable price for Charlestown. On the other hand, the board has reached the conclusion that the Charlestown company may no longer reasonably charge its customers more than the present price in Cambridge, and a part of Somerville, and that there is nothing in the present condition of the company's affairs or in its future prospects to render such a reduction commercially impracticable or inexpedient."

New York Public Service Commission, Second District

In re Application of Rochester, Corning, Elmira Traction Company for Authority to Issue Bonds and Stock

Second Ann. Report (*for* 1908), *pp.* 20, 155, 179, 182.

In this matter (March, 1908), the Commission passed upon the application of the Traction Company, a newly organized railroad, for authority to issue mortgage bonds and capital stock, and laid down the following rules for the division of the capitalization between stock and bonds to be applied whenever practicable:

> "(1) An estimate will be made, from consideration of the results of operation of existing roads, of the probable gross earnings.
>
> (2) An estimate will be made in like manner of the probable operating expenses, taxes and depreciation charges.
>
> (3) The excess of earnings over the disbursements, which must be made before fixed charges can be met, represents the sum which is applicable to fixed charges.
>
> (4) The maximum bond issue which will be allowed, must be determined by the sum thus ascertained to be applicable to the payment of the interest charge.
>
> (5) No bond issue should be permitted creating an interest charge beyond an amount, which it is reasonably certain can be met from the net earnings.
>
> (6) Stock, representing a cash investment, should be required to an amount sufficient to afford a moral guaranty, that in the judgment of those investing, the enterprise is likely to prove commercially successful."

On rehearing (p. 179) bonds were authorized to be issued to the extent of $1,000,000 to be sold at not less than 85% (p. 155) when stock to the amount of $380,000 had been subscribed by responsible parties, and such subscription proved to the Commission.

Extract From the Opinion of the Massachusetts Board of Gas and Electric Light Commissioners

In the matter of Rates of Edison Electric Illuminating Company of Boston

(24th Annual Report, p. 20)

Here the Public Franchise League of Boston claimed that the rates of the Boston Edison Company were exorbitant and discriminating, and that the rate system was intricate, complex, and not generally understood. Hearings in the matter by the Commission were had from February, 1907, to November, 1907.

The theory of the Company's rates was claimed by it to be, to charge each customer substantially the cost to it of supplying him, *including a reasonable return* on the investment made in his behalf; in other words, the basis was the cost of service to each individual customer. The Company claimed that, "the costs of an electric lighting company are actually the sum of what its customers' costs would be, if they supplied themselves under the different conditions under which they consume current, less such deduction as is justified by the use of the same plant by different customers, and such deduction as is justified by the greater economy of the company's larger plant."

The commission held that the justification of a system of individual rates must rest upon the practicability of ascertaining, with reasonable accuracy, the cost of supplying each individual customer, and of automatically apportioning this cost to him by the schedule of prices adopted; further, that the Company should be able to demonstrate that it is possible to ascertain individual costs with reasonable accuracy. The Commission was of the opinion that no differential system of rates for a public utility could be equitably and properly based solely upon the cost to the Company of supplying the individual. It stated that it was not convinced that it was practicable, even though desirable, to ascertain the respective costs to the Company of its individual customers, and to apportion such cost in the prices charged, either under the system used by the Company, or under any other known to the Board.

The conclusion of the Board was, that the Company should offer to sell electricity for any use at a uniform price, not to exceed 12c per kw. hour, and that if a customer should elect to be served under the existing schedule, whenever the average price per kw. hour charged to him for any year exceeded such uniform price, his account should be adjusted so that he should not pay more than such uniform price.

The Company was left free to establish lower rates for service to customers, who were in a position to otherwise serve themselves. In other words, rates based on the demand system might continue to be offered in order to get competitive business. The Commission in its decision said:

> "A kilowatt hour is now the established unit for measuring electricity. It represents a definite amount of electrical energy. It will do exactly the same amount of work for one customer as for another. Unless a customer can consider seriously generating his own electricity, the value to him of each kilowatt hour furnished by the company has no necessary relation either to demand, quantity or length of use. If, however, he can seriously consider supplying himself, these factors may affect his own cost, and therefore the price which he might be willing to pay the company instead of installing his own plant.
>
> "In the second place, the use of electricity for light and power has grown with great rapidity during the past two decades, and while it may be generated and used even in small quantities on private premises, yet as a practical matter it is impossible for every individual to manufacture electricity for himself. Most of the members of a community must seek a supply from some common agency, or not enjoy its use. To serve this need, and to promote the public welfare and convenience, the company has been given substantially exclusive privileges to extend its lines throughout the territory which it supplies.
>
> "The company has, therefore, a public duty to perform, and is bound to discharge this duty for the equal benefit of all. It is also to be remembered that it has but one service to render its customers, namely, to supply them with electricity. The company conceded that it cannot, consistently with its duty to the community, supply A and refuse to supply B, both being within reach of its lines. It is equally clear that to charge A one price and B another for the same service under like conditions is a violation of duty. In a proper conception of the nature of this duty, mere difference in size of customers does not of itself constitute such a difference in conditions as to justify a difference in price. But the company contended that in any event variations in length of use of a given demand constitute such differences in condition as to warrant differences in price. Here again, however, it is plain that such differences in price must be justified, if at all, because of reasonably proportional differences in cost of service, and yet it has already been set forth that this consideration, even on the

company's theory, must frequently yield to considerations of the nature of the customer's use of electricity, and that at best the company can assign the costs of supplying its customers only on broad lines, and upon certain general assumptions and averages. Due weight should be and has been given to the necessity and desirability of increasing the efficiency of the plant without increasing the investment, in order thereby to decrease the average cost of the electricity produced. It may be admitted as a general truth that, other conditions being equal, length of use of a given demand has an influence upon the company's costs. But unless the variations in use are sufficiently marked, it is apparent that their influence upon costs is slight, and, therefore, with respect to the great majority of customers they are practically negligible. The Board is also not convinced that this consideration is so controlling as to warrant the conclusion that such conditions necessarily create individual differences in cost upon which different prices to customers may properly be based.

"If all the customers of the company were dependent upon it for a supply, it is believed that there would be little occasion to discuss or attempt to justify differential rates, and that a uniform meter rate, determined by reasonable operating costs and a fair return on the investment reasonably necessary for the public convenience, would prevail universally. It may be conceded that, if a uniform meter rate prevailed, there would be some unprofitable customers. This may be predicated with truth of any system of rates for a public service. The Board is of the opinion, however, that this view of such a rate is exaggerated, and that in any event it is likely to result in no greater amount of injustice than in an attempt to make every customer theoretically, if not actually, profitable. There can be no more desirable requisite for every public service charge than that it shall be simple, definite and readily understood and applied. Even its most ardent advocates do not claim that these characteristics are inherent in the demand system.

"In an analysis of the last year of the company's business, the non-contract lighting customers were in point of numbers 15,000 out of 20,000 approximately, or 75 per cent of the whole number of customers. * * * * * Those customers who cannot manufacture electricity for themselves, and whose needs and convenience the company is bound to serve, are chiefly of this non-contract class. Whatever view may be taken of the matter, the conditions under which customers so situated use electricity are not so unlike as to make a uniform meter rate work any substantial injustice to them. Neither is there any sufficient advantage to the company, in the present system of rates as applicable to this class, to compensate for the complications and misunderstandings which they introduce. The board is of the opinion that, in view of these considerations and in place of the present so-called non-contract lighting rates, the company *should offer to sell* electricity to its customers for any use at a uniform meter rate.

"In distinction from the large body of customers just mentioned there is a considerable number, both actual and possible, who may readily supply themselves with light or obtain power from some other source. To such customers the value of the service furnished by the company will depend

to a considerable extent on the probable cost of supplying themselves. If the company is to supply them, it is subject to the ordinary rules of business competition—it must meet prices established by conditions which it does not create and cannot control, or not do the business. The prices which an electric light company must thus meet or not do business are determined not by an open market, but largely by individual conditions, which differ widely with different customers. Had the company not taken the initiative in offering prices which have attracted this business, and the customers now under consideration were attempting to compel the company to serve them at prices which fitted their respective conditions, it is probable that they could not compel the company to serve them except at a price open to all. On the other hand, should the company now refuse to serve its customers save at a uniform price, or uniform prices, for lighting and power respectively, as some have suggested, it is equally probable that the immediate effect would be a considerable loss in the volume of its business. The question arises whether or not the existing practice of the company in respect to its prices or business of this character is so far inconsistent with its recognized duty to serve all without discrimination that it should no longer be tolerated.

"In considering this question it must not be forgotten that the advantage enjoyed by a customer, whose use of electricity will warrant the installation of his own supply of electricity or power, is one which the company cannot prevent. It is equally to be remembered that there is always a strong temptation to the manager of a public service, if unrestrained, to maintain a high rate for business which he controls while making disproportionate concessions to get that which can take care of itself. Experience is also making more and more evident that the duty of one who undertakes a public service must necessarily deprive him of the right to base his policies upon many practices common to and even commendable in private business.

"In reaching out for additional business by making concessions from the average rate, it is plain that the only justification for permitting the continuance of such a policy is that this additional business will be for the benefit of the large body of customers who must pay the regular rate. For it is not the advantage of the few but rather the advantage of the many which should be the controlling test. In the opinion of the Board this "competitive" business, if it may be so termed, is of such value in the present development of the company that it may be of substantial advantage to the customer who must pay the regular rate. In fact, the only means by which the average lighting customer can hope to see the price to him materially reduced through a greater increase in the volume of the business relative to the company's investment. Long use of a customer's installation, especially during parts of the day or year when otherwise a considerable proportion of the company's plant is standing idle, even at very low rates, provided they reasonably exceed proper "running costs," may yield a revenue otherwise not available, which will materially help to dilute the company's general expenses, and should lead, as the business of the company develops, to the steady reduction of the price to the regular customer.

"The customers who have just been under discussion are now supplied almost wholly under the yearly lighting, elevator and power schedules. It is under these three schedules, and especially the latter, that the most substantial increases have been made this past year in the company's business. While this is an indication that the prices are sufficiently low to attract business, yet the evidence submitted at the hearings does not justify the conclusion that the company is taking business under these schedules at a loss, and thus imposing a burden on the average customer. Of course, with respect to the so-called "competitive" customers, it is clear that prices should not be determined by special bargain in each case, and, on whatever basis offered by the company, should be free to all desiring a supply under like conditions. The demand system, whatever its faults in determining the individual's cost to the company, has at least the merit of recognizing the most essential elements determining the probable cost to the individual of supplying himself, and therefore operates to fit the price which the company must make to get his business to his actual conditions. To the extent to which this business is really competitive it will take care of itself. For these reasons the Board makes no recommendations with respect to these schedules, although believing that some readjustment with a view to their simplification upon broader and more uniform lines may be wisely undertaken.

"The Board is aware of the danger of abuse in permitting concessions to some customers not granted to all. It is also aware that the terms "non-competitive" and "competitive" cannot be applied to the company's customers with precision, and that, if used, they may not describe with absolute strictness the present non-contract lighting as distinguished from the yearly lighting, power and elevator customers. But the Board believes that these terms recognize as existing certain economic conditions attending the sale of electricity which, in the interest of the many whose needs and convenience the company should serve, seem to warrant a continuance of certain differences in prices, not as a permanent policy, but until the uniform rate recommended can from time to time be safely reduced so low as to be in itself an encouragement to the unrestricted use of electricity for all purposes."

The foregoing is an authority upon the proposition that rates should not be made to meet individual conditions; that the rate to the individual should not be based solely on the cost to the company of supplying the individual (which cost, of course, includes profit); but that all rates must to a certain extent be *average* rates. It follows therefore, that a rate to a *class* cannot include merely class cost plus a fixed percentage of profit; for the same reasons that were held to forbid individual rates, indicate that in fixing class rates it is not necessary to apportion to each class the same percentage of profit.

Extract From the Speech of Hon. Joseph W. Bailey Delivered Before the New York State Bar Association

At Rochester, New York, January 20, 1910, on the Subject of "The Power to Regulate Transportation Charges by Statutory Enactment"

"I can not, however, accept the doctrine that a railroad is entitled to such rates as will yield a fair return on the value of its property irrespective of the value of its service; nor will I agree that a railroad can be required to render a service for less than a just compensation in order to reduce its net income to a fair return on its property. The power to regulate the charges of a common carrier was never conferred on any government for the purpose of enabling it to prevent losses or to limit profits; but it is designed, always and only, for the protection of the people against overcharges. If one railroad constructed through a sparsely settled region can not render enough services at a just compensation for each, to yield a fair return on its value, that is the misfortune of those who have invested their money in such an enterprise; and it can not practice an extortion against those who must patronize it in order to earn dividends for its stockholders. On the other hand, if another railroad constructed through a region with a dense population can render services enough, rendering each at a just compensation, to net its owners fifteen per cent on their investment, that is their good fortune, and the legislature has no power to reduce the rates on that railroad below a just compensation in order to reduce its dividends to what either legislators or judges may deem a fair return on the value of its property.

* * * * *

"I do not doubt that in determining what is a just compensation for the use of any property, it is proper, and even necessary, for us to consider the value of that property in connection with the services which it may render; but all such testimony, however essential it may be to an intelligent decision of the case, is merely a means to an end, and is not the end itself. When a railroad seeks to condemn my property it is competent for me to prove what I paid for it, or it

is competent for the railroad to do so; but that evidence, whether introduced by the railroad company or by me, is not conclusive, and it is admissible only because it will tend to prove what will be a just compensation for the property which the railroad desires to take. If I bought the property for less than its value, the railroad cannot take the benefit of my bargain, nor can I make it bear the burden of my bad judgment, if I paid more than the property was worth. Even if I had purchased the property at a fair price, it might, from its situation, concurring with some peculiar circumstance, double or divide its price in a single year; but the railroad would not be permitted to share my profit in the one case nor compelled to suffer my loss in the other. The test—and the only test—would be the fair market value of the property at the time when the railroad was seeking to take it, or if it should happen to be a property without a market value, then its value would be ascertained under the other rules of law; and as the railroad must pay me a just compensation for my property without reference to whether that will net me a profit or leave me a loss, so when I come to take the railroad's service I must pay—and it can only demand of me—a just compensation for that service no matter whether it is rendered at a profit or at a loss. Exactly as it was competent for me to prove or for the railroad to prove what my property had cost me, so it is competent for the railroad to prove or for me to prove what its property has cost the railroad company; but the cost of my property and the cost of the railroad's property are purely evidential, and are intended to aid us in fulfilling the constitutional requirement that the railroad shall pay me a just compensation for my property, and that I shall pay the railroad company a just compensation for its service.

"Many who concede the technical correctness of this rule object to it upon the ground that it is almost impossible to apply it in practice. It is undoubtedly true that we cannot determine the value of a railroad service with the same certainty that we can measure cloth or weigh sugar; but it is equally true that we can not fix values and damages with absolute precision in any proceeding to condemn private property for a public use. I have participated in the trial of many condemnation cases, and I have seen honest men and good citizens differ widely in their testimony as to the value of the property actually taken and the damages to the remainder of the tract. I have seen one witness of high standing and absolute integrity place value and damages at double as much as another witness of equal character and standing had placed them. In such cases I could well

understand how badly perplexed the jury must have been in arriving at a verdict; but it never once entered my mind that we ought, on that account, to abrogate the rule which gives an owner the fair value of his property, and substitute, on account of its simplicity, a rule giving him his original investment with a fair profit added to it. *To reject the ancient and constitutional rule that guarantees all private property against being taken for a public use without a just compensation and accept this new and indefensible one of a fair profit on the investment because it is easier of application, is equivalent to saying that we will adopt an illogical and unconstitutional test for the purpose of relieving ourselves from the performance of a very tedious and a somewhat difficult duty.*

"If those who are so ready to accept a wrong rule in order to escape the trouble of applying a right one, will look a little deeper into this question, they will find that in this case, as in all others, a departure from a sound legal and constitutional principle will lead us into difficulties rather than lead us out of them. I believe that I can demonstrate that the rule which we are asked to approve because it is a practical one will produce almost endless mischief. It will permit the most palpable favoritism to some shippers, and the grossest injustice against others; it will invite a discrimination between communities and commodities; and it cannot be equally and impartially applied to all railroads.

"One serious vice of the rule which permits railroads to charge any rate necessary to earn a fair return on the value of their property is that it treats the whole schedule of railroad rates as a single question, and thus permits the favoritism, the injustice, and the discrimination which I have mentioned. If the railroad is entitled to earn a fair return on its property, then the test would be whether its receipts over and above its expenditures exceed that fair return; and would not permit an inquiry into the reasonableness of each rate, because to do so would bring us back to the very question of a just compensation for each particular service. It would, therefore, result that whenever any shipper challenged a particular rate the railroad could answer by showing that after deducting its expenses from its receipts the balance amounted to only a fair return on the value of its property. Will any intelligent man contend for a rule like that? Do you think the railroad could successfully answer my complaint that it was overcharging me by proving the value of its property, its expense, and its receipts, and thus showing that the

difference between what it had taken in and paid out left it only a fair return on its investment? That might be entirely true; but it might be true because some shippers had been charged less than they ought to have paid, and it could not excuse itself for overcharging me by proving that it had undercharged someone else. Let me state a concrete case. Will any intelligent man say that the railroad could answer my complaint against excessive rates on my cattle which it had carried from Texas to Chicago by showing that it had carried cattle from Wyoming to Chicago for half of what they ought to have paid? Such an answer would aggravate rather than remove my grievance.

"Not only would this rule permit inequalities as between shippers; but it would encourage discriminations between communities and commodities. Let us suppose that one part of a railroad traversed a mineral region and another part an agricultural region. Would any man defend its action either as a matter of justice or as a matter of law if it should impose a very high rate on the products of the farm and grant a very low rate on the products of the mine? And yet if the law only requires that the railroad shall have a fair return on the value of its property, it could defend itself in any court by showing that its net income did not exceed that limit. What a mockery of law and justice it would be to permit the railroad to answer the farmer's complaint of high charges against him by proving low charges against the miners, and thus establishing that the result of the combined charges brought only a fair return on its investment.

"But the mischief would not end with individual shippers or classes. It would disorganize and destroy our railroad system itself. Let us suppose that there were two parallel and competing lines serving practically the same territory, and in many cases exactly the same towns and cities. Let us suppose that one was constructed by wise and prudent men under the most favorable circumstances and cost sixty thousand dollars per mile. Let us suppose that its competing line was built with equal judgment and economy, but that the cost of the right-of-way and terminals was greater, and that a proper grade necessitated deeper cuts and higher fills, thus increasing the cost of the road-bed until the actual cost aggregated eighty thousand dollars per mile. If these two roads are each entitled to earn a fair return on their investment and we estimate that fair return at six per cent, the one road must earn thirty-six hundred

dollars per mile, and the other must earn forty-eight hundred dollars per mile each year. Assuming that both are operated with equal economy and judgment, it must be obvious to any man that the first road can earn its annual charge of thirty-six hundred dollars per mile at a lower rate on a given tonnage than the other road must charge in order to earn its forty-eight hundred dollars per mile. Therefore, when you come to fix the rates so as to let each road earn its six per cent you must fix a lower rate on the cheaper road and a higher rate on the costlier road. What would be the immediate and inevitable result of such an arrangement? The traffic of that territory would instantly be diverted from one road to the other, and the rates would soon call for a readjustment. How would you readjust them? The cheaper road, on account of its increased volume of tonnage, would be earning more than six per cent under the rate which had already been fixed; and the costlier road, in consequence of its diminished tonnage, would be earning less than its six per cent. Would you raise the rate on the costlier road and lower it on the cheaper one with the expectation of increasing the income of the one and reducing the income of the other? You could not correct the inequality that way, because as you lowered the rate on the cheaper road and raised the rate on the costlier road you would divert still more tonnage from the second to the first, and it would soon become apparent that no law could make the earnings of each equal to the same return on the unequal value of their property.

"Nor is this all. To notify the railroads that they can earn a fair return on their property and no more, will destroy the incentive which induces railroad managers to build new lines and improve their old ones. If men who manage their railroads with superior skill and judgment can have no better profit than others who manage them with ordinary skill and judgment, we will soon reach a point where all progress in railroad management and development will cease; and that would be a disaster which I think no thoughtful man is willing to invite."

Extracts From Testimony of Mr. E. P. Ripley, President of the Atchison, Topeka & Santa Fe Railway Company, Given Before the Interstate Commerce Commission Special Examiners at Chicago, August 29 and 30, 1910

(Testimony Published in Full Under Title "Why Railroads Need Higher Rates")

In the last ten years the earnings on the capitalization (of the Santa Fe system) have been something less than 6 per cent. * * * * Furthermore, the capitalization does not represent the value of the property. * * * * The property could not be reproduced today for its capitalization. * * * * When an institution as large as ours is standing still, it begins to go backward.

We do not think that we ought to be required to sell our bonds at a discount; but if the people who have the money differ with us in that respect, we are really helpless. * * * * The ideal condition of course is that we should be able to sell *our stock at par.*

Q. Would you not say that a railroad situated like the Santa Fe with its earning power, if it had adequate earnings would sell its securities at par?

A. If its earnings were such as to give the public confidence that dividends could be maintained at a reasonable rate, considering the risk, there would be no difficulty in selling its *stock at par.* Some railroads are fortunate enough to do that. The Pennsylvania, I think, has issued no bonds for a good many years. It always has obtained the money for necessary improvements by selling its stock. That is the *ideal condition.*

Q. What is your idea as to what improvements should be made out of the earnings and what out of capitalization? That is to say, should the rates in this case be increased so that improvements may be made directly from the earnings?

A. Well, in part. There are certain classes of expenditure that should be made from earnings always rather than from the sale of either stock or bonds.

Q. For example?

A. Well, for example, a very large class of expenditures that return no interest, upon which there is no probability and no possibility of any direct return either in saving of expenditures or increasing the earnings. In that class are the various restrictions and improvements demanded by municipalities, where we are obliged, for instance, to elevate our tracks in the city. That is something the return from which financially from a railroad standpoint amounts to nothing. It is of safety to the public, convenient to the public, and in a certain way it is a convenience to the railroad; but the interest on the cost of an improvement of that kind is ten or twenty or thirty times any benefit that accrues from it to the railroads themselves.

The question of the proper distribution of the burden of such expenses between capital and earnings is one that can be argued on both sides and argued almost indefinitely, but it is my belief that the present generation should join in the expense of those matters —that the railroads should be allowed to pay for them out of earnings in order that the entire burden may not be put in capital and thus settled on posterity.

A railroad company certainly should be sufficiently strong financially to take care of it (obsolescence), either by improvement —either by a stated charge to depreciation or by improvements made out of earnings which would offset any depreciation that there may be. For instance, a station building which is entirely adequate today or was entirely adequate when it was built fifteen years ago, becomes inadequate, and it has to be torn down and cast away and replaced with another building. I have already said that I think these things should be largely, if not entirely, *made out of earnings, and that provides in a way for obsolescence or depreciation.* The general custom has been, I think, fully to maintain the properties out of earnings wherever that was possible, wherever there were earnings enough; and that full maintenance accompanied perhaps with some improvement has been supposed to take care of the deprecia-

tion, so that there has never been any actual charge for depreciation on roadway and track. But whichever way it is done, it amounts to the same thing; you either raise enough money from the public to take care of those things out of earnings or you should charge enough in rates to take care of them by charging depreciation to expenses.

There never was any better definition of a reasonable rate than that which was given many years ago by somebody, and which has been used as a byword and a reproach ever since, namely, "what the traffic will bear." That is the best definition that ever was given of it. That does not mean all the traffic will bear, it does not mean all that can be extorted or squeezed out of it, but what the traffic will bear having regard to the freest possible movement of commodities, the least possible burden on the producer and on the consumer.

Q. What do you think the Sante Fe should earn on its investment in order to have money to pay adequately its stockholders, to make the improvements necessary, to borrow money, to have the credit to borrow it at low rates, and to serve the public to the fullest proper capacity?

A. That of course is a matter of judgment. That would vary with different roads. So far as the Sante Fe is concerned, I think we ought to earn double what we pay in dividends at least. For instance, if we pay six per cent in dividends, I think we ought to earn 12 per cent on our stock, if not more; certainly not less than that.

Q. What do you think you ought to pay in dividends to the shareholders?

A. Well, that is a matter of judgment. I do not think we ought to pay less than six per cent in order to make the stock reasonably attractive and keep our credit up.

The question before the Commission is primarily what is the value of the service we are rendering to the shipper. Incidentally that value has necessarily been enhanced by increased expenses and increased wages, by increased valuation, by incomplete and inade-

quate returns on capital. Those are all factors, but the prime factor is what is it worth to the shipper.

The ideal way or the way I would do things if I could, would be to collect from the public perhaps as much each year as would equal an amount of dividends we paid, and to invest it in the property without any additional capitalization.

Summary of Testimony of Mr. James McCrea, President of the Pennsylvania Railroad, Given Before the Interstate Commerce Commission, at Washington, Oct. 13, 1910

(Copied by Permission from Railway Age Gazette, Issue of October 21, 1910)

The Pennsylvania system east of Pittsburgh has cost very much more than the capitalization represents. On that capitalization it has never paid more than a fair return—less, in fact, than most other characters of investment, such as manufacturing, mining and agriculture. The results of constant increases in its business have been distributed either through reductions in rates, increases in amounts paid for wages and material, or by reinvestments in the property not capitalized. It has always been typical of good and constantly improved service—in fact, the character of service which, if I understand the American people, they desire perpetuated and improved. A railway system of this character being so capitalized and rendering a service which is not only of the highest character, but satisfactory to the public and to its patrons, deriving as it did in the year 1909 *net earnings* to the amount of but *5.01 per cent of the amount actually invested* in the property, it is difficult for me to understand how a system of rates which secures such results can be regarded as on too high a basis.

The Pennsylvania Railroad Company has for many years past, as a result of its operations, realized a substantial surplus in each year over and above the amount required to enable it to meet its interest charges and pay moderate dividends on its stock to its stockholders. This surplus has varied in amount from year to year. For the last ten years the average has been about $12,000,000 a year, practically all of which has been expended on the property for the purpose of enabling the company to conduct its operations more safely, more efficiently and more cheaply.

Since the passage of the Interstate Commerce Act in 1887 the amounts expended on the property of the lines east of Pittsburgh

out of the earnings and from other sources than the proceeds of the sale of bonds or stock or other securities aggregate $262,000,000, and the company was enabled to provide almost all of this large sum out of the surplus earnings derived from the operation of its property. The Pennsylvania Railroad and many of the roads embraced in its system were built at a time when it was difficult to secure capital for such enterprises. The country through which the roads were built was at that time comparatively thinly settled and the business light. The character of the construction, which was suitable for the time and the existing conditions, was, to a large extent, unsuited to later conditions. The safety of the public and of employees required elimination of grade crossings of highways, the use of safety appliances and the use of improved material and equipment, all of which in themselves do not yield much, if any, net return, and it was to meet these conditions and to adapt its road and equipment to modern requirements that the uncapitalized earnings in the form of surplus have been so freely spent. Had these earnings not been available, and had they not been expended for the purposes indicated, the Pennsylvania Railroad would today be a very different railway and would have been wholly unable to render the service to the public which it is today rendering. The accumulation of the surplus earnings which have been thus expended has only been possible because the rates of freight in force since the passage of the Interstate Commerce Act have been sufficient to realize for the company amounts in excess of its expenses, taxes, interest and dividends.

The fact that these surplus earnings were being earned in each year has not been a matter that has been concealed from the public, but, on the contrary, the existence of the surplus and the disposition made of it have not only been public property, but the method or practice pursued by the company in providing in part, at least, for the necessary additions to and improvement of its property in this manner has been generally and publicly commended and approved. It is vitally important that in the future the company should be enabled to continue to pursue the policy which has guided it in the past, and to provide in part, at least, for future additions and improvements out of surplus earnings. It is fairly to be expected that the company will be required to make as great expenditures in the future as it has made in the past. An enormous amount of work remains to be done, for which additional funds will have to be secured. The public of

today is demanding a service of a far more costly character than ten or twenty years ago was expected or desired, and in order to make the improvements required to meet the constantly increasing demands of this character and to furnish a service which, according to modern views and standards, the public, in a sense, has a right to ask for, large expenditures must continue to be made upon the property, and if this company is to meet these conditions and is to continue to progress and not to go backward (because there is no such thing as a large railway system standing still), it must continue to derive earnings from its operations, not merely sufficient to enable it to make a fair return to its stockholders, but sufficient to earn a surplus which can be expended on the property sufficiently large to maintain the credit which it has established.

In the last ten years the Pennsylvania Railroad Company has expended upon its property out of income upward of $116,000,000 and has also secured, through the sale of its stock, exclusive of premiums, to the amount of about $275,000,000, and through the increase of its bonded debt, exclusive of car trusts ($25,000,000) of about $172,000,000. Its ability to sell its stock and bonds has been due to the fact that it has not merely paid dividends of 6 per cent or 7 per cent, chiefly the former, but that it has been able to show at the end of the year large surplus earnings, which it has put back into the property.

When investors have been asked to purchase its stock or bonds the company has been able to show that it was then in receipt of enough income to enable it to make a fair return on the securities that it proposed to issue, even if the proceeds of these securities could not be so invested as to enable the company to derive an immediate return thereon. In other words, the existence of the surplus earnings established a credit which enabled the company to secure the additional funds necessary to make improvements or additions as these became necessary.

What would have been the condition if the company's earnings had been so restricted in the past as to prevent it from accumulating surplus earnings available for the improvement of its property? If the $262,000,000 which has been thus expended on the lines east of Pittsburgh had been realized through a sale of securities these securities would have had to have been sold at a price which could have been realized for them, and if the earn-

ings of the company had been such as to barely cover the amounts required to meet its interest and dividends on its then outstanding securities, the prices realized for any additional issues of securities would have been such that the additional charges to which the company would have been subjected would have today necessitated rates higher than those which have been prevailing, in order to enable the company merely to meet its interest and dividend charges.

But there is another feature to be borne in mind in this connection, and that is that a large part of the $262,000,000 thus expended upon the property has been spent for purposes which would hardly justify an increase of its capital. Take, for instance, the amounts expended in changes of line in order to eliminate curves or to reduce grades. In almost all cases of expenditures of this character the old line is abandoned. Take, also, the large amounts which have been spent in the elevation of the railway through cities and many other items of a like character. Expenditures of this character, which do not result in any additions to the property which would tend to increase its gross earnings or revenue, ought not, where it is possible to avoid it, to be treated as capital expenditures.

During all the period that these large expenditures were being made—mainly out of surplus earnings—one of the main purposes that the company had in view was the reduction in the cost of transportation. Throughout this period the general trend of wages has been upward, and the same has been true of its taxes and of many other items which enter into and affect operating cost. Increased cost resulting from these features has been largely met by the reduction in cost resulting from expenditures made for this purpose, and thus it has been possible to avoid constant and frequent increases in rates of freight which otherwise would have had to have been made in order to enable the company to meet its increased operating cost.

In the present year the expenses of the companies whose lines are embraced in what is known as the "Pennsylvania lines east of Pittsburgh" have increased, due to an increase in the rate of wages paid to their employees, between $7,000,000 and $8,000,000 per year, and it is necessary for this company in some way to recoup itself for this additional tax on its income. Heretofore

in similar cases this has been accomplished partially by advances in rates and partially through economies resulting from reductions in grades, increased hauling capacity of locomotives, increased capacity of cars and increased volume of business.

So far as concerns economies which will result from reductions in grades, increased hauling capacity of locomotives and increased capacity of cars, the companies are today already practically deriving the full benefit from those which are possible in this direction, due to expenditures heretofore made, for we have practically completed our grade reductions and have probably reached the maximum size for our cars and engines. And it is to be borne in mind in this connection that we are now largely unable to secure the benefit of increased economies resulting from larger engines and cars and reduced grades with respect to our preference freight trains, in which the merchandise class traffic as a rule is transported, due to the fact that the amount hauled by these trains is limited by higher speed and the maximum grades over which they must pass, this being necessary in order to avoid the breaking up of the trains at transfer points.

For the last three years there has been practically no growth in business. The records of 1910 will show that the business of that year is below that of 1907. I do not mean that it should be inferred from this that there is not, in my opinion, going to be any future growth in business, but east of the Mississippi, at least in my judgment, it is going to be at a markedly slower rate than in the past, and with that growth will probably come a diminishing length of haul, thereby tending to reduce the gross earnings of the companies. But even if our gross earnings are to continue to grow as the result of growth in business, the additional net earnings that will be derived from the increased business will in all probability fall very far short of making good the additional cost put upon the companies by the wage increase.

That this is true is largely demonstrated by the results of the company's operations for the five months following the advance in wages. In these five months the gross earnings of the lines east of Pittsburgh increased about $6,700,000, while the net earnings (including in the expenses expenditures heretofore made for additions and betterments, in order to enable a comparison to be made with last year, when expenditures of the same character were also included in operating expenses) decreased about $3,000,000.

Treating these months as typical months—and there is no reason why they should not be regarded as such—and extending the figures so as to embrace a year's business on this basis, the result would be that with increased gross earnings of about $16,000,000, there would be a decrease in the net earnings of about $7,200,000. The results of the five months' operation already referred to have also shown that (treating again the expenditures heretofore made for the additions and betterments as part of the operating expenses, in order to enable a comparison to be made), the operating ratio has risen from 69.70 per cent in 1909 to 75.51 per cent in 1910, an increase of almost 6 per cent. There is no reason, in my judgment, for expecting that further increases of gross earnings will tend materially to reduce this operating ratio, except to the extent to which increased rates of freight will tend to do this. The company will therefore in the future be obliged to expend for operating expenses probably not less than 75 per cent of any increased earnings which it may derive, but the 25 per cent which will be thus left will not represent surplus earnings; thus, for example, gross earnings of the Pennsylvania Railroad Company in the year 1909 exceeded those for the year 1900 by about $66,000,000, the operating expenses, including taxes, increased $52,000,000 and the net earnings about $14,000,000.

But in this same period the investment of the company in the property from which this income was derived had increased to the extent of $288,000,000. Interest on this amount at the rate of 6 per cent would be more than $17,000,000, so that of the increased earnings of 1909, which, as has already been said, amounted to $66,000,000, $52,000,000 was absorbed by operating expenses and taxes, leaving $14,000,000 net earnings, or $3,000,000 less than the interest on the amount necessary to secure them.

In my judgment, therefore, it would be wholly unsafe to assume that the company will, as a result of the growth of its business, be enabled to recoup itself for the depletion in its surplus revenue, which is certain to result from a continuance of the present operating cost. Under these conditions I feel that it is essential, in the interest of the public and of shippers, as well as of the railway company itself, that it should be permitted to secure through an advance in rates the amount which represents its additional outlay on account of the advance in wages in order that its surplus earnings may continue at approximately the rate at which they have been

running in the past. It will require the expenditure of more than these surplus earnings to enable the company to keep pace with the demands of the public and of its shippers, and unquestionably additional capital must be secured in the future. If we are to obtain this we must not only be in a position to make a fair return on it, but we must be able to show a margin of safety in our earnings.

I believe, generally speaking, that what I have said in regard to the Pennsylvania Railroad as to the necessity for the rate advance is equally true of almost all railways in the United States, certainly those which are conservatively managed and which are endeavoring to give the public such a service as they have a right to expect.

JOHN BORNMAN & SON, DETROIT